

Comparison of Speedometer Test Results between Static and Dynamic Methods in Two-Wheeled Motorcycle Type Approval

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Abstract: Vehicle speedometer testing is an important component of vehicle type approval to ensure that the indicated speed is evaluated using standardized testing procedures. At the Indonesian Vehicle Testing and Certification Center (BPLJSKB), speedometer testing can be conducted using a static method with a speedometer tester or a dynamic method based on a GPS/GLONASS antenna. The different measurement environments and principles may produce variations in the resulting speedometer values. This study aimed to compare speedometer test results obtained using static and dynamic methods for a two-wheeled motorcycle under controlled testing conditions. A quantitative comparative method with an experimental approach was employed. Each testing method was repeated 25 times at reference speeds of 40 km/h and 80 km/h, resulting in 100 observations. The data were analyzed using descriptive statistics, normality and homogeneity tests, an Independent Samples t-test, and Cohen's d effect size analysis. The results showed no statistically significant difference between the static and dynamic methods, with p-values of 0.15 at 40 km/h and 0.10 at 80 km/h. The mean differences were 0.13 km/h and -0.17 km/h, respectively, while the absolute Cohen's d values were 0.41 and 0.47. These findings indicate statistically comparable results under the experimental conditions, although they do not establish full interchangeability between the two methods.

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INTRODUCTION

The speedometer is an essential vehicle instrument because it provides the driver with information about vehicle speed and supports safe vehicle operation. In the context of vehicle type approval, speedometer performance must be evaluated through standardized testing procedures to ensure that the indicated speed complies with applicable technical requirements. In Indonesia, the testing and type approval of motor vehicles are regulated through national provisions, including Government Regulation of the Republic of Indonesia Number 55 of 2012 concerning Vehicles and Minister of Transportation Regulation Number PM 33 of 2018 concerning Motor Vehicle Type Testing (Indonesia, 2012, 2018). These national requirements are also aligned with the international regulatory framework established in UN Regulation No. 39, which specifies provisions concerning the approval of vehicles with regard to speedometer and odometer equipment, including their installation (United Nations, 2017).

In the implementation of motorcycle type approval testing, speedometer performance may be evaluated using different measurement approaches. At the Indonesian Vehicle Testing and Certification Center (BPLJSKB), testing can be performed using a static speedometer tester or a dynamic testing method based on a Global Navigation Satellite System (GNSS), including

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GPS/GLONASS technology. Although both approaches are intended to evaluate vehicle speedometer performance, they employ different measurement principles and testing environments. The static method determines speed based on the rotational behavior of the motorcycle wheel in contact with a testing roller, whereas the dynamic method determines vehicle speed during actual vehicle movement using a GNSS-based reference measurement system. These differences may introduce variations associated with tire-roller interaction, tire condition, vehicle operation, satellite signal reception, and reference-speed stability.

Previous studies have demonstrated that the characteristics of speed-measurement technology can influence the resulting measurement performance. Steinmetz et al. (2014) investigated GPS-derived speed as a reference for verifying speed-measuring devices and reported that GPS-based measurements could provide sufficiently low measurement uncertainty under controlled conditions. Similarly, Supej and Čuk (2014) compared several Global Navigation Satellite System (GNSS) devices for speed tracking in road and transport applications and found that GNSS systems could provide measurements comparable to vehicle speedometers during steady-speed operation. However, they also reported that measurement errors and latency may vary among devices, particularly during acceleration and deceleration. These findings indicate that the suitability of GNSS-based speed measurement depends not only on the measurement technology itself but also on the operating conditions under which the measurement is performed.

The reliability of GNSS-based measurements is also influenced by satellite signal quality and antenna characteristics. Dong and Hua (2022) reviewed developments in GNSS anti-multipath antenna designs and emphasized the importance of antenna characteristics in reducing multipath effects that may affect positioning performance. More recently, Krzan et al. (2024) examined low-cost GNSS antennas for precise positioning and highlighted the influence of multipath effects and antenna phase-center characteristics on positioning performance. Therefore, when GNSS-based measurements are used as a reference in dynamic vehicle testing, the characteristics and installation of the antenna as well as the surrounding measurement conditions need to be considered.

Apart from GNSS-related factors, differences in speed-measurement technologies should also be evaluated in terms of measurement accuracy and uncertainty. Shim and Kim (2022) compared GPS-type and noncontact optical-type speed sensors through vehicle testing and demonstrated the importance of assessing measurement accuracy when different speed-measurement technologies are compared. This perspective is particularly relevant when comparing static and dynamic speedometer testing because the two methods do not directly measure vehicle speed using identical physical principles.

Vehicle conditions may also contribute to variation in speedometer test results. Firdaus (2023) reported that tire inflation pressure affected the results obtained from a speedometer tester. This finding is important because the static testing method involves direct interaction between the motorcycle tire and the tester roller. Variations in tire pressure or tire characteristics may consequently influence wheel-roller interaction and the resulting speed measurement. Therefore, controlling vehicle conditions, particularly tire inflation pressure, is necessary to minimize experimental variation when comparing different speedometer testing methods.

Experimental testing also requires appropriate control of testing conditions to ensure that observed differences can be attributed as much as possible to the measurement methods rather than uncontrolled experimental factors. Yulianti et al. (2024) emphasized that experimental research

requires systematic control of research variables and testing conditions to obtain reliable and interpretable results. Accordingly, controlling vehicle condition, environmental conditions, testing equipment, reference speed, and test procedures is important when conducting a direct comparison between static and dynamic speedometer testing.

Despite the development of GNSS-based speed measurement and the availability of previous studies concerning individual speed-measurement technologies, empirical evidence regarding the direct comparison between roller-based static speedometer testing and GNSS-based dynamic testing for motorcycle type approval remains limited. Previous studies have predominantly focused on the accuracy or uncertainty of individual measurement technologies, GNSS performance, antenna characteristics, or the influence of vehicle conditions on speedometer tester measurements (Steinmetz et al., 2014; Supej & Čuk, 2014; Dong & Hua, 2022; Shim & Kim, 2022; Firdaus, 2023; Krzan et al., 2024). Consequently, there remains a need for an experimental comparison of the results produced by static and dynamic testing methods when applied to the same motorcycle under controlled testing conditions.

The novelty of this study lies in its direct experimental comparison of roller-based static speedometer testing and GNSS-based dynamic speedometer testing for a two-wheeled motorcycle at two reference speeds, namely 40 km/h and 80 km/h. Rather than evaluating only the performance of a particular speed-measurement technology, this study examines whether the two testing approaches produce statistically comparable speedometer test results under a controlled experimental framework. In addition to statistical significance testing, the magnitude of the observed differences is evaluated using Cohen's *d* effect size, thereby providing complementary information regarding the practical magnitude of the differences between the two testing methods.

Therefore, this study aims to compare motorcycle speedometer test results obtained using static and dynamic testing methods at reference speeds of 40 km/h and 80 km/h. Specifically, the study evaluates whether statistically significant differences exist between the two testing methods and determines the magnitude of the observed differences using Cohen's *d* effect-size analysis. The findings are expected to provide empirical evidence regarding the comparability of static speedometer tester measurements and GNSS-based dynamic measurements within the experimental conditions examined in this study.

RESEARCH METHOD

This study employed a quantitative comparative experimental approach to examine the differences between static and dynamic speedometer testing methods on a two-wheeled motorcycle for type approval. A quantitative approach was used because the study involved numerical measurement data obtained directly from experimental testing, while the comparative design was intended to identify differences in speedometer measurement results between the two testing methods (Aida et al., 2025; Siroj et al., 2024). The experimental approach was selected because the testing conditions were controlled and the measurements were obtained through direct observation of the motorcycle under specified test conditions (Hasanah & Albina, 2025; Yulianti et al., 2024).

Research Design and Data Collection

The research data consisted of primary data obtained directly from speedometer testing using static and dynamic methods. Primary data were collected through repeated experimental

measurements under predetermined test conditions. Direct measurement in controlled experimental conditions allows the obtained data to represent the actual performance of the tested instruments under the specified operating conditions (Muslimin et al., 2024; Noval et al., 2025; Yulianti et al., 2024).

The experiment was conducted at two target speeds, namely 40 km/h and 80 km/h. Each testing condition was repeated 25 times for both the static and dynamic methods. Thus, the experiment generated 100 measurement observations, consisting of 25 observations for the static method and 25 observations for the dynamic method at each target speed. Repeated measurements were conducted to obtain a sufficient set of observations for statistical analysis and to reduce the influence of random variation during individual measurements.

The test vehicle was a two-wheeled motorcycle used as the experimental object. Before testing, the vehicle was prepared under controlled conditions to maintain consistency between measurements. The motorcycle was tested using the same vehicle, rider, and general test conditions for both measurement methods. The tire pressure was maintained at 29 psi for the front tire and 33 psi for the rear tire. The test was conducted with dry tires and under dry environmental conditions to minimize external factors that could affect the measurement results. Tire pressure was controlled because previous research has demonstrated that tire pressure can influence the results obtained from speedometer testing (Firdaus, 2023).

The rider's weight was maintained at approximately 75 kg in accordance with the loading provisions specified in United Nations Regulation No. 39 concerning the approval of vehicles with regard to the speedometer and odometer equipment. The use of a consistent rider load was intended to maintain comparable loading conditions throughout the experimental measurements (United Nations, 2017).

Static Speedometer Testing

The static test was conducted using a speedometer tester in which the motorcycle wheel was positioned on a roller mechanism. The roller was rotated at the predetermined test speed, while the motorcycle speedometer indication was recorded as the static measurement result.

The static testing method represents a controlled laboratory-based measurement in which the rotational movement of the roller is used to simulate the movement of the motorcycle wheel during vehicle operation. Because the motorcycle remains stationary while the wheel rotates on the roller, the method provides a controlled environment for measuring the speedometer indication without requiring the motorcycle to travel on a road surface.

For each target speed of 40 km/h and 80 km/h, the motorcycle was tested repeatedly using the same procedure. The speedometer indication displayed during each test was recorded and subsequently used for statistical analysis.

Dynamic Speedometer Testing

The dynamic test was performed by operating the motorcycle under actual movement conditions. Vehicle speed was measured using a VBox Data Logger equipped with a GNSS-based positioning system using GPS/GLONASS signals. The GNSS measurement was used as the reference measurement for determining the actual dynamic vehicle speed.

GNSS-based speed measurement has been widely investigated for vehicle and motion measurement applications. Previous studies have demonstrated the capability of GNSS-based systems

to determine vehicle speed and track movement, although measurement performance can be influenced by positioning conditions and signal quality (Steinmetz et al., 2014; Supej & Čuk, 2014). The performance of GNSS measurement can also be affected by antenna characteristics and multipath effects; therefore, appropriate antenna configuration and measurement equipment are important in obtaining reliable positioning data (Dong & Hua, 2022; Krzan et al., 2024).

During dynamic testing, the motorcycle was operated at the predetermined target speeds of 40 km/h and 80 km/h. The speedometer indication and the speed recorded by the VBOX Data Logger were subsequently documented for each repetition. The same vehicle and general testing conditions were maintained throughout the dynamic measurements.

Measurement Procedure

The overall experimental procedure consisted of several stages. First, the motorcycle and measurement equipment were prepared and checked before testing. Second, the motorcycle was tested using the static speedometer tester at the target speeds of 40 km/h and 80 km/h. Third, the motorcycle was tested dynamically using the VBOX Data Logger and GNSS-based measurement system at the same target speeds. Each test condition was repeated 25 times.

The measurement results from both methods were then compiled into a dataset for statistical analysis. The static and dynamic measurements were analyzed separately for the 40 km/h and 80 km/h test conditions. This separation was intended to determine whether the difference between the two measurement methods varied according to the target testing speed.

Data Analysis

The collected data were analyzed using descriptive and inferential statistical methods. Descriptive statistics were first used to summarize the central tendency and dispersion of the measurements obtained from each testing method. The descriptive analysis included the mean and standard deviation, which provide an overview of the measurement characteristics and variability of the experimental data (Harahap et al., 2025; Subhaktiyasa et al., 2025).

Before conducting the inferential analysis, the normality of the data was examined using the Shapiro-Wilk test. The normality test was used to determine whether the measurement data satisfied the distributional assumption required for subsequent parametric statistical analysis (Ahadi & Zain, 2023; Isnaini et al., 2025).

The homogeneity of variance between the static and dynamic measurement groups was subsequently evaluated using Levene's test. Homogeneity testing was conducted to determine whether the variances of the two measurement groups were statistically comparable before performing the comparison test (Al Fatih et al., 2026).

An independent-samples t-test was then used to evaluate whether a statistically significant difference existed between the speedometer measurements obtained using the static and dynamic testing methods at each target speed. The significance level was set at $\alpha = 0.05$. A p-value greater than 0.05 was interpreted as indicating that the observed difference between the two groups was not statistically significant under the experimental conditions.

In addition to statistical significance testing, Cohen's d was calculated to quantify the magnitude of the difference between the two measurement methods. Effect-size analysis was included because statistical significance alone does not describe the practical magnitude of an observed difference. The

combination of descriptive statistics, hypothesis testing, and effect-size analysis provides a more comprehensive assessment of the comparability of the two measurement methods (Syafriani, 2021).

All statistical analyses were conducted separately for the 40 km/h and 80 km/h test conditions. The results were subsequently interpreted by considering both statistical significance and the magnitude of the observed differences between the static and dynamic measurements.

RESULTS AND DISCUSSION

The test results

The test results obtained from the static and dynamic testing methods are presented in Tables 1 and 2.

Table 1. Test Results of the Static Testing Method at Reference Speeds of 40 km/h and 80 km/h

Test Results of the Static Testing Method									
No	Speedometer Reading (km/h)	Test Results		Error (%)	No	Speedometer Reading (km/h)	Test Results		Error (%)
		km/h	%				km/h	%	
1	40	36,74	91,85	-8,15	1	80	74,98	93,73	-6,27
2	40	37,09	92,73	-7,27	2	80	75,25	94,06	-5,94
3	40	37,10	92,75	-7,25	3	80	75,27	94,09	-5,91
4	40	37,63	94,08	-5,92	4	80	74,79	93,49	-6,51
5	40	36,42	91,05	-8,95	5	80	75,28	94,10	-5,90
6	40	36,39	90,98	-9,03	6	80	74,33	92,91	-7,09
7	40	36,83	92,08	-7,93	7	80	74,18	92,73	-7,27
8	40	37,28	93,20	-6,80	8	80	75,55	94,44	-5,56
9	40	37,45	93,63	-6,37	9	80	74,49	93,11	-6,89
10	40	36,48	91,20	-8,80	10	80	74,79	93,49	-6,51
11	40	36,74	91,85	-8,15	11	80	74,56	93,20	-6,80
12	40	36,15	90,38	-9,63	12	80	74,77	93,46	-6,54
13	40	36,38	90,95	-9,05	13	80	74,63	93,29	-6,71
14	40	36,38	90,95	-9,05	14	80	74,79	93,49	-6,51
15	40	36,45	91,13	-8,87	15	80	74,85	93,56	-6,44
16	40	36,50	91,25	-8,75	16	80	74,89	93,61	-6,39
17	40	36,71	91,78	-8,23	17	80	75,15	93,94	-6,06
18	40	36,74	91,85	-8,15	18	80	75,25	94,06	-5,94
19	40	36,98	92,45	-7,55	19	80	75,27	94,09	-5,91
20	40	36,64	91,60	-8,40	20	80	74,19	92,74	-7,26
21	40	36,70	91,75	-8,25	21	80	74,23	92,79	-7,21
22	40	36,73	91,83	-8,18	22	80	74,21	92,76	-7,24
23	40	36,88	92,20	-7,80	23	80	74,20	92,75	-7,25
24	40	37,01	92,53	-7,48	24	80	74,44	93,05	-6,95
25	40	37,05	92,63	-7,38	25	80	74,59	93,24	-6,76

Table 2. Test Results of the Dynamic Testing Method at Reference Speeds of 40 km/h and 80 km/h

Test Results of the Dynamic Testing Method									
No	Speedometer Reading (km/h)	Test Results		Error (%)	No	Speedometer Reading (km/h)	Test Results		Error (%)
		km/h	%				km/h	%	
1	40	36,97	92,43	-7,58	1	80	74,80	93,50	-6,50
2	40	37,04	92,60	-7,40	2	80	75,20	94,00	-6,00
3	40	37,07	92,68	-7,33	3	80	74,97	93,71	-6,29
4	40	37,13	92,83	-7,17	4	80	74,79	93,49	-6,51
5	40	37,36	93,40	-6,60	5	80	74,78	93,48	-6,53

6	40	37,03	92,58	-7,43	6	80	74,73	93,41	-6,59
7	40	37,01	92,53	-7,48	7	80	75,31	94,14	-5,86
8	40	36,51	91,28	-8,73	8	80	74,82	93,53	-6,48
9	40	36,74	91,85	-8,15	9	80	74,30	92,88	-7,13
10	40	36,71	91,78	-8,23	10	80	74,59	93,24	-6,76
11	40	36,97	92,43	-7,58	11	80	75,02	93,78	-6,23
12	40	36,93	92,33	-7,68	12	80	75,07	93,84	-6,16
13	40	36,67	91,68	-8,33	13	80	74,32	92,90	-7,10
14	40	36,81	92,03	-7,97	14	80	74,90	93,63	-6,37
15	40	36,47	91,18	-8,83	15	80	74,74	93,43	-6,58
16	40	36,93	92,33	-7,68	16	80	75,33	94,16	-5,84
17	40	36,39	90,98	-9,03	17	80	75,11	93,89	-6,11
18	40	37,36	93,40	-6,60	18	80	75,33	94,16	-5,84
19	40	36,67	91,68	-8,33	19	80	74,72	93,40	-6,60
20	40	37,51	93,78	-6,23	20	80	75,02	93,78	-6,23
21	40	37,36	93,40	-6,60	21	80	75,31	94,14	-5,86
22	40	36,71	91,78	-8,23	22	80	75,46	94,33	-5,68
23	40	36,70	91,75	-8,25	23	80	74,89	93,61	-6,39
24	40	37,03	92,58	-7,43	24	80	74,73	93,41	-6,59
25	40	36,81	92,03	-7,97	25	80	74,97	93,71	-6,29

The test results at each reference speed were subsequently compared according to the testing method and presented in graphical form. The corresponding graphs are presented in Figures 1 and 2.

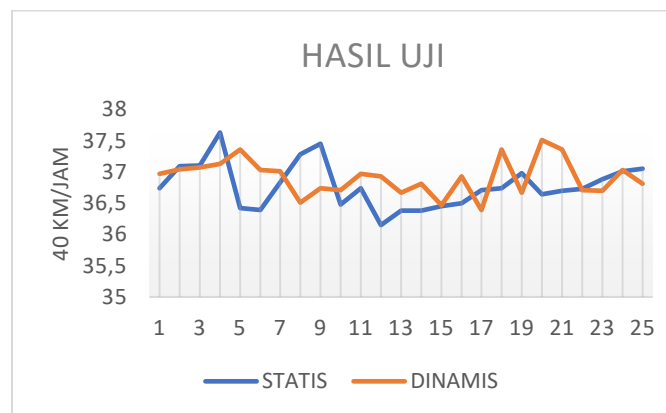


Figure 1. Graph of the Test Results for Each Testing Method at the Reference Speed of 40 km/h

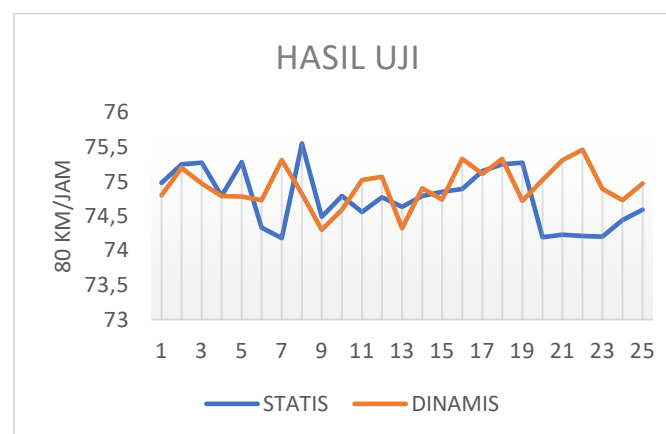


Figure 2. Graph of the Test Results for Each Testing Method at the Reference Speed of 80 km/h

Descriptive analysis

Descriptive analysis was conducted to obtain an initial overview of the characteristics of the collected data, thereby facilitating the identification of data patterns and supporting the interpretation of subsequent statistical analyses. The results of the descriptive analysis are presented in Tables 3 and 4.

Table 3. Results of the Descriptive Analysis at the Reference Speed of 40 km/h

Descriptives		Statistic	Std. Error
STATIC_40	Mean	36.78	.07
	Median	36.74	
	Variance	.13	
	Std. Deviation	.36	
	Minimum	36.15	
	Maximum	37.63	
	Range	1.48	
DYNAMIC_40	Mean	36.91	.06
	Median	36.93	
	Variance	.08	
	Std. Deviation	.29	
	Minimum	36.39	
	Maximum	37.51	
	Range	1.12	

Table 4. Results of the Descriptive Analysis at the Reference Speed of 80 km/h

Descriptives		Statistic	Std. Error
STATIC_80	Mean	74.76	.08
	Median	74.79	
	Variance	.17	
	Std. Deviation	.41	
	Minimum	74.18	
	Maximum	75.55	
	Range	1.37	
DYNAMIC_80	Mean	74.93	.06
	Median	74.90	
	Variance	.09	
	Std. Deviation	.30	
	Minimum	74.30	
	Maximum	75.46	
	Range	1.16	

Shapiro-Wilk

The collected data were subsequently subjected to a normality test using the Shapiro-Wilk test. The results of the Shapiro-Wilk test for both data groups are presented in Tables 5 and 6.

Table 5. Results of the Shapiro-Wilk Test at the Reference Speed of 40 km/h

Tests of Normality						
	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
STATIC_40	.14	25.00	.20 [*]	.96	25.00	.46
DYNAMIC_40	.10	25.00	.20 [*]	.97	25.00	.57

Table 6. Results of the Shapiro-Wilk Test at the Reference Speed of 80 km/h

	Tests of Normality					
	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
STATIC_80	.12	25.00	.20 [*]	.94	25.00	.12
DYNAMIC_80	.12	25.00	.20 [*]	.96	25.00	.43

Levene's Test

The results of Levene's Test for both data groups are presented in Tables 7 and 8.

Table 7. Results of the Levene's Test at the Reference Speed of 40 km/h

Test of Homogeneity of Variance					
	Levene Statistic	df1	df2	Sig.	
TEST RESULT	Based on Mean	.95	1.00	48.00	.34

Table 8. Results of the Levene's Test at the Reference Speed of 80 km/h

Test of Homogeneity of Variance					
	Levene Statistic	df1	df2	Sig.	
TEST RESULT	Based on Mean	3.43	1.00	48.00	.07

Independent Samples t-test

The results of the Independent Samples t-test are presented in Tables 9 and 10.

Table 9. Results of the Independent Samples t-Test at the Reference Speed of 40 km/h

Independent Samples Test										
		Levene's Test for Equality of Variances				t-test for Equality of Means				
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
TEST RESULT	Equal variances assumed	.95	.34	-1.45	48.00	.15	-.13	.09	Lower	Upper
									-.32	.05

Table 10. Results of the Independent Samples t-Test at the Reference Speed of 80 km/h

Independent Samples Test										
		Levene's Test for Equality of Variances				t-test for Equality of Means				
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
TEST RESULT	Equal variances assumed	3.43	.07	-1.67	48.00	.10	-.17	.10	Lower	Upper
									-.38	.03

Effect Size Cohen's d

The results of the Cohen's d effect size analysis are presented in Tables 11 and 12.

Table 11. Results of the Cohen's d effect size at the Reference Speed of 40 km/h

Independent Samples Effect Sizes					
		Standardizer ^a	Point Estimate	95% Confidence Interval	
				Lower	Upper
TEST RESULT	Cohen's d	.33	-.41	-.97	.15

Table 12. Results of the Cohen's d effect size at the Reference Speed of 80 km/h

Independent Samples Effect Sizes					
		Standardizer ^a	Point Estimate	95% Confidence Interval	
				Lower	Upper
TEST RESULT	Cohen's d	.36	-.47	-1.03	.09

DISCUSSION

Descriptive analysis

The descriptive results indicate that the mean speedometer readings obtained from the static and dynamic methods were close at both reference speeds. At 40 km/h, the static method produced a mean value of 36.78 km/h, while the dynamic method produced 36.91 km/h. At 80 km/h, the corresponding mean values were 74.76 km/h and 74.93 km/h.

Although the mean values were similar, differences were observed in the dispersion of the measurements. At 40 km/h, the standard deviation was 0.36 km/h for the static method and 0.29 km/h for the dynamic method. At 80 km/h, the standard deviation was 0.41 km/h for the static method and 0.30 km/h for the dynamic method. Thus, the dynamic method showed lower dispersion under both reference-speed conditions.

This difference in dispersion may be related to the measurement principles of the two methods. The static method determines speed through the rotational behavior of the motorcycle wheel in contact with a testing roller. Consequently, small variations in tire-roller interaction, wheel loading, or stabilization of the wheel speed may contribute to measurement variation. In contrast, the dynamic method determines vehicle speed using a GNSS-based measurement system during actual vehicle movement. Under the controlled track conditions used in this study, the GNSS system may have provided a relatively stable reference during the measurement periods.

However, the lower dispersion observed in the dynamic method should not be interpreted as evidence that the dynamic method is universally more accurate. GNSS-based speed measurements may also be influenced by receiver characteristics, signal quality, sampling frequency, and vehicle motion. Previous research has shown that GNSS performance can vary according to receiver quality and dynamic conditions, particularly during acceleration and deceleration (Supej & Čuk, 2014). Therefore, the observed difference in dispersion should be interpreted specifically within the experimental conditions of this study..

Shapiro-Wilk

Tables 5 and 6 present the results of the normality tests for the data obtained from both testing methods at the reference speeds of 40 km/h and 80 km/h. The significance (*Sig.*) values reported in

the Shapiro–Wilk column were 0.46 and 0.12 for the static testing method, and 0.57 and 0.43 for the dynamic testing method. Since all significance values were greater than 0.05, the null hypothesis (H_0) was accepted, indicating that both datasets were normally distributed. Based on these results, the collected data were considered suitable for further statistical analysis.

Levene's Test

Tables 7 and 8 present the results of the homogeneity tests for the data obtained from both testing methods at the reference speeds of 40 km/h and 80 km/h. The significance (Sig.) values reported in the two tables were 0.34 and 0.07, respectively. Since both significance values exceeded the homogeneity test criterion of 0.05, the null hypothesis (H_0) was accepted, indicating that the data exhibited homogeneous variances and satisfied the assumptions required for the Independent Samples t-test.

Independent Samples t-test

The Independent Samples t-test showed no statistically significant difference between the static and dynamic testing methods at either reference speed. At 40 km/h, the two-tailed significance value was 0.15, with a mean difference of -0.13 km/h and a 95% confidence interval ranging from -0.32 to 0.05 km/h. At 80 km/h, the significance value was 0.10, with a mean difference of -0.17 km/h.

Because both p-values were greater than the significance level of 0.05, the null hypothesis was not rejected. Therefore, the statistical analysis did not provide sufficient evidence of a difference between the speedometer test results obtained using the static and dynamic methods under the conditions examined in this study.

The negative mean differences indicate that the mean values obtained using the static method were slightly lower than those obtained using the dynamic method. However, the magnitude of these differences was small relative to the reference speeds. This result suggests that differences in the measurement environment and measurement principle between the roller-based static method and the GNSS-based dynamic method did not produce a statistically detectable difference in the measured speedometer values under the experimental conditions.

The result is generally consistent with previous research showing that GNSS-based vehicle speed measurements can provide results comparable to other vehicle speed measurement systems under controlled or steady-speed conditions (Steinmetz et al., 2014; Supej & Čuk, 2014). Nevertheless, those studies evaluated GNSS measurement performance rather than the direct comparability of static and dynamic speedometer testing for motorcycle type approval. Therefore, the present study extends the discussion by examining the two testing approaches within the same experimental motorcycle and controlled testing framework..

Effect Size Cohen's d

The Cohen's d analysis yielded point estimates of -0.41 at 40 km/h and -0.47 at 80 km/h. The negative signs indicate the direction of the mean difference, with the static method producing slightly lower mean values than the dynamic method. For interpreting the magnitude of the effect, the absolute values of Cohen's d were considered, resulting in effect sizes of 0.41 and 0.47, respectively.

These effect sizes indicate relatively small practical differences between the two testing methods. The result complements the t-test findings because statistical significance and effect magnitude provide different information: the t-test evaluates whether the observed difference is

statistically detectable, whereas Cohen's d describes the magnitude of that difference relative to data variability.

At both reference speeds, the observed effect remained limited. Therefore, although the static and dynamic methods produced slightly different mean values, the magnitude of the difference was relatively small under the experimental conditions examined in this study. These findings support the interpretation that the two methods produced comparable results within the scope of the present experiment, but they do not by themselves establish that the methods are fully interchangeable..

Measurement Principle

The difference in measurement dispersion can also be considered from the characteristics of the measurement systems. In the static method, the speedometer reading is influenced by the rotational behavior of the driven wheel on the tester roller. The interaction between the tire and roller may vary slightly from one repetition to another because of differences in wheel stabilization and tire-roller contact conditions. Previous research has demonstrated that tire pressure can influence speedometer tester results, supporting the importance of controlling tire-related conditions during static testing (Firdaus, 2023).

In the dynamic method, vehicle speed was obtained from a GNSS-based measurement system during actual vehicle movement. GNSS-based speed measurement has been shown to provide useful reference information for vehicle speed verification, although its performance depends on receiver quality and operating conditions (Steinmetz et al., 2014). Supej and Čuk (2014) also reported that GNSS systems can provide accurate speed measurements during steady-speed operation, while errors and latency may increase under acceleration and deceleration. In the present study, the dynamic measurements were performed under controlled track conditions and at predefined reference speeds. These conditions may have contributed to the relatively lower dispersion observed in the dynamic measurements.

Therefore, the lower dispersion of the dynamic method should be interpreted as an observation specific to the present experimental conditions rather than as evidence that GNSS-based testing is inherently superior to roller-based testing.

Literature Comparison

The findings of the present study can be interpreted in relation to previous research on vehicle speed measurement. Steinmetz et al. (2014) demonstrated that GPS-derived speed could provide a sufficiently precise reference for the verification of speed-measuring devices under controlled conditions. The present study similarly found that a GNSS-based dynamic measurement system produced results that were close to those obtained using a conventional static speedometer tester. However, the focus of the present study differs because the comparison concerns two speedometer testing methods rather than the verification of a traffic-enforcement measurement device.

Supej and Čuk (2014) reported that GNSS devices could provide speed measurements comparable to vehicle speedometers during steady-speed operation, while differences in performance could occur during acceleration and deceleration. This finding is relevant to the present study because the dynamic test involved maintaining a relatively stable reference speed during the measurement section of the track. The controlled operating condition may therefore have reduced the influence of dynamic speed fluctuations on the GNSS measurement.

The present findings are also consistent with the study by Shim and Kim (2022), which emphasized the importance of evaluating measurement uncertainty when comparing different vehicle speed measurement technologies. Their research compared GPS-based and optical speed sensors using real-vehicle testing, whereas the present study directly compares a roller-based speedometer tester and a GNSS-based dynamic method. Thus, the contribution of the present study lies in applying the comparison specifically to motorcycle speedometer testing within the context of vehicle type approval.

In addition, Firdaus (2023) demonstrated that tire pressure can influence speedometer tester results. This finding supports the importance of maintaining controlled tire pressure in the present experiment. In this study, tire inflation pressure was maintained according to the manufacturer's specified condition to minimize variation associated with tire characteristics.

Overall, the findings are broadly consistent with previous research indicating that vehicle speed measurements can be affected by measurement technology and operating conditions. The present study extends this body of research by directly comparing static roller-based and dynamic GNSS-based speedometer testing for a two-wheeled motorcycle at two reference speeds. Nevertheless, the comparison remains limited to the experimental conditions examined in this study.

Study Limitations

This study has several limitations that should be considered when interpreting the findings. First, the experiment was conducted using only one two-wheeled motorcycle and one test rider. Therefore, the findings may not represent variations associated with different motorcycle models, vehicle specifications, tire characteristics, or rider behavior.

Second, the comparison was limited to two reference speeds, namely 40 km/h and 80 km/h. Consequently, the findings cannot necessarily be generalized to other operating speeds. Third, the tests were conducted under specific environmental and test-track conditions, including dry conditions and a controlled testing environment. Changes in road surface, weather, temperature, wind conditions, or GNSS signal quality may influence the measurement results.

Fourth, although each testing condition was repeated 25 times, the experiment involved a limited number of vehicles, riders, and testing conditions. The sample therefore represents repeated observations under a controlled experimental condition rather than a broad population of motorcycles.

Finally, this study focused on differences in mean test results and effect size. A dedicated agreement analysis, such as Bland–Altman analysis or another method-comparison approach, was not performed. Therefore, the findings should be interpreted as evidence of statistical comparability under the experimental conditions rather than definitive evidence that the static and dynamic methods are interchangeable.

Future studies should involve multiple motorcycle models and riders, a wider range of reference speeds, different environmental conditions, larger datasets, and dedicated agreement analyses to further evaluate the equivalence and interchangeability of the two testing methods.

CONCLUSION

Based on the experimental results, the static speedometer testing method and the dynamic GNSS-based testing method produced statistically comparable results for the two-wheeled motorcycle examined at reference speeds of 40 km/h and 80 km/h. The Independent Samples t-test

showed no statistically significant difference between the two methods, with p-values of 0.15 and 0.10, respectively. The mean differences were -0.13 km/h at 40 km/h and -0.17 km/h at 80 km/h, while the absolute Cohen's d values were 0.41 and 0.47, indicating relatively small effects.

The findings indicate that the difference between the two testing methods was limited under the experimental conditions examined in this study. However, the results should not be interpreted as definitive evidence of full equivalence or interchangeability between the two methods. The study was limited to one motorcycle, one rider, two reference speeds, specific environmental conditions, and repeated observations under a controlled test setup. Further research involving multiple motorcycle types, riders, reference speeds, environmental conditions, larger datasets, and dedicated agreement analyses is required to establish the broader applicability and interchangeability of the two testing methods.

REFERENCES

- Ahadi, G. D., & Zain, N. N. L. E. (2023). The simulation study of normality test using Kolmogorov-Smirnov, Anderson-Darling, and Shapiro-Wilk. *Eigen Mathematics Journal*, 6(1), 11-19. <https://doi.org/10.29303/emj.v6i1.131>
- Aida, A., Hermina, D., & Norlaila, N. (2025). Jenis data penelitian kuantitatif (korelasional, komparatif, dan eksperimen). *Al-Manba: Jurnal Ilmiah Keislaman dan Kemasyarakatan*, 10(1), 31-40. <https://doi.org/10.69782/almanba.v10i1.48>
- Al Fatih, F., Lubis, N. P., HSB, K. N., Zulpan, Z., & Arianto, A. (2026). Konsep homogenitas dan normalitas dalam statistik serta teknik pengujiannya. *Educational Journal*, 1(3), 805-817. <https://doi.org/10.63822/b98bqe88>
- Dong, J., & Hua, Q. (2022). Overview and progress of GNSS anti-multipath antenna designs. *Sensors and Machine Learning Applications*, 2(3), 3. <https://doi.org/10.55627/smla.002.03.00026>
- Firdaus, D. H. (2023). *Pengaruh tekanan angin ban kendaraan Mitsubishi L300 terhadap hasil uji speedometer tester* [Laporan/Tugas akhir]. Politeknik Keselamatan Transportasi Jalan.
- Harahap, Y. A., Nasution, R. P., & Amir, A. (2025). Peran ukuran pemusatan dan penyebaran data dalam analisis statistika. *Pendas: Jurnal Ilmiah Pendidikan Dasar*, 10(4). <https://doi.org/10.23969/jp.v10i04.38955>
- Hasanah, N. U., & Albina, M. (2025). Hakikat desain eksperimental: Pendekatan konseptual dan implikasinya dalam penelitian kuantitatif. *QAZI: Journal of Islamic Studies*, 2(1), 179-186. <https://doi.org/10.61104/qz.v2i1.276>
- Indonesia. (2012). *Peraturan Pemerintah Republik Indonesia Nomor 55 Tahun 2012 tentang kendaraan*.
- Indonesia. (2018). *Peraturan Menteri Perhubungan Republik Indonesia Nomor PM 33 Tahun 2018 tentang pengujian tipe kendaraan bermotor*.
- Isnaini, M., Afgani, M. W., Haqqi, A., & Azhari, I. (2025). Teknik analisis data uji normalitas. *J-CEKI: Jurnal Cendekia Ilmiah*, 4(2), 1377-1384. <https://doi.org/10.56799/jceki.v4i2.7007>
- Krzan, G., Dawidowicz, K., & Paziewski, J. (2024). Low-cost GNSS antennas in precise positioning: A focus on multipath and antenna phase center models. *GPS Solutions*, 28(3). <https://doi.org/10.1007/s10291-024-01645-3>
- Muslimin, I., Farid, M., & Mandra, M. A. S. (2024). Analisis kinerja battery charging menggunakan tenaga surya untuk kendaraan roda dua. *Jurnal Pendidikan Vokasi Otomotif*, 7(1), 1-12. <https://doi.org/10.21831/jpvo.v7i1.73491>
- Noval, R., Sumarsono, D. A., Adhitya, M., Heryana, G., Zainuri, F., Tullah, M. H., & Todaro, M. (2025). Performance evaluation and accuracy analysis of a chassis dynamometer for light electric vehicles. *World Electric Vehicle Journal*, 16(3), Article 170. <https://doi.org/10.3390/wevj16030170>

- Shim, J.-R., & Kim, B.-C. (2022). Comparison of measurement accuracies of GPS-type and noncontact optical-type speed sensors by vehicle test. *Journal of the Korean Society of Manufacturing Process Engineers*, 21(10), 22–29. <https://doi.org/10.14775/ksmpe.2022.21.10.022>
- Siroj, R. A., Afgani, W., Fatimah, Septaria, D., Zahira, G., & Salsabila. (2024). Metode penelitian kuantitatif pendekatan ilmiah untuk analisis data. *Jurnal Review Pendidikan dan Pengajaran*, 7.
- Steinmetz, E., Jarlemark, P. O. J., Emardson, R., Skoogh, H., & Herbertsson, M. (2014). Assessment of GPS derived speed for verification of speed measuring devices. *International Journal of Instrumentation Technology*, 1(3), 212–227. <https://doi.org/10.1504/IJIT.2014.065160>
- Subhaktiyasa, P. G., Candrawati, S. A. K., Sumaryani, N. P., Sunita, N. W., & Syakur, A. (2025). Penerapan statistik deskriptif: Perspektif kuantitatif dan kualitatif. *Jurnal Edukasi Matematika dan Sains*, 14(1), 96–104. <https://doi.org/10.59672/emasains.v14i1.4450>
- Supej, M., & Čuk, I. (2014). Comparison of Global Navigation Satellite System devices on speed tracking in road (tran)sport applications. *Sensors*, 14(12), 23490–23508. <https://doi.org/10.3390/s141223490>
- Syafriani, D. (2021). Pembelajaran statistika dengan metode tutorial menggunakan aplikasi SPSS untuk meningkatkan kemampuan statistik mahasiswa. *JS (Jurnal Sekolah)*, 5(2), 10–15. <https://doi.org/10.24114/js.v5i2.26302>
- United Nations. (2017). *UN Regulation No. 39: Uniform provisions concerning the approval of vehicles with regard to the speedometer and odometer equipment including its installation*. United Nations Economic Commission for Europe.
- Yulianti, R., Syukrilla, W. A., Effendi, Febriyanti, T. L., Rahayu, D. S., Agung, B. H., Oktariantio, M. L., Koto, S. K., Rahmawan, S., Asmara, A., Awaluddin, Sidabutar, Y. A., Krisma, D. A., Adi, N. R. M., & Zulaeha, O. (2024). *Metode penelitian eksperimen: Konsep, implementasi, dan studi kasus*. PT Mifandi Mandiri Digital.