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Review article

# The motorcycle rider behaviour questionnaire as a predictor of crashes: A systematic review and meta-analysis

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A B S T R A C T

The aim of the present review was to analyze the overall predictive ability of the Motorcycle Rider Behaviour Questionnaire (MRBQ) in regard to self-reported crashes. Therefore, the study examined the relationship between MRBQ factors (traffic error, control error, speed violation, and usage of safety equipment) and self-reported crashes using meta-analysis. The Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines were used to select published studies, and was undertaken in three databases: Google Scholar, PubMed, and Web of Science. Articles were required to focus on examine the relationship between riding behaviour and crash involvement using MRBQ. The random effect model of meta-analysis observed a small but significant effect of the factor "speed violation" on crashes ($r = 0.11$ [0.06, 0.15], $p < 0.001$). Further, age ($r = 0.06$ [−0.09, 0.2], $p < 0.001$) and riding experience ($r = -0.4$ [−0.84, 0.37], $p < 0.001$) were observed as significant predictors of crashes. The moderator analysis revealed only one dichotomous moderator, i.e., rider type. Overall, meta-analysis results revealed that the MRBQ has a lower predictive ability for crashes. Future studies should follow large sample validation with recorded crashes or by identifying alternate variables for crashes as a criterion. The implications of present study lie in providing a focused and quantitative analysis of which specific MRBQ factor is the most and least impactful. Furthermore, because the study focused on the predictive validity of MRBQ in relation to crashes, it provides a reference for additional MRBQ implications (e.g., relationship with psychological measures) to further investigate MRBQ's applicability.

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## 1. Introduction

Driving behaviour plays a critical role in traffic crashes [1,2]. Literature reported that driving behaviour was the cause of approximately 74% road crashes [3]. Particularly, motorcycle riders perform more risky riding behaviour compared to other modes of transport [4]. Therefore, numerous research has been done to understand the influence of riding behaviour on crash risk. Majorly four different methods of riding behaviour data collection techniques are available in literature, viz., self-reported, driving or riding simulator based, naturalistic driving study and in-depth crash investigation. In past studies, the self-reported method was most widely used to understand riding behaviour [5–7]. Self-reporting is a method in which riders are asked about their feeling, attitude, and beliefs to understand the rider's behaviour while riding. These data are collected through questionnaires, interviews, or polls without any interference from the interviewer. The self-reporting of riding behaviour acts as a useful tool in such cases when collecting riding data by direct observations and official records is not possible [8].

Elliot et al. [6] developed a Motorcycle Rider Behaviour Questionnaire (MRBQ) based on the Driver Behaviour Questionnaire (DBQ) developed by Reason et al. [9]. DBQ mainly consists the questions related to the driving behaviour of car drivers, LCV drivers, and HCV drivers. It does not consist the questions specifically related to motorcycle riders such as questions related to helmet use, safety equipment's, stunt performance etc. Therefore, Elliot et al. [6] modified the standard DBQ by adding some questions which were related to driving behaviour of motorcycle riders. The developed MRBQ consisted of 43 items describing a variety of riding behaviour, and offered a report of how a rider behaves in various traffic conditions and accident involvement. The participants were also questioned to report their demographic and past crash information. All the items were subjected to exploratory factor analysis to categorize the riding behaviour in different factors, and the 5-factor solution (traffic errors, control errors, speed violations, stunts, and safety equipment) was adopted using the scree plot method [6]. The factor solution identifies the relationship between the items and the factors, and organizes the correlated items into a single factor. Elliott et al. [6] factor solution did not perfectly replicate the factor solution proposed by Reason et al. [9] due to the dissimilarities in driving style of Motorcyclists and other road users. However, the error factor (considered in DBQ) was also explored in the case of MRBQ, but it is further divided into two categories i.e., traffic error and control error. Error term replicates the performance limit of the rider, for instance, those associated with perceptual, attentional, and cognitive abilities [10]. Whereas, the violation term replicates the intentional deviations from the rules and regulations made for safer traffic movement [6]. Elliott et al. [6] introduced two additional factors, i.e., stunts and safety equipment use, which are more applicable in the case of a motorcycle rider. It was reported in the study that riders with higher riding mileage and young age riders are associated with higher crash risk, and traffic error behaviour was the leading cause of all crashes [6].

Several studies have implemented the MRBQ and examined its applicability for different countries since Elliott et al. [6]. Previous research has looked at how an individual rider's demographic characteristics influence their riding behaviour and crash involvement in order to determine risky riding behaviour using MRBQ. Age and riding miles (riding hours per week), for example, are significant factors in a PTW rider's crash risk. Previous studies have shown that crash risk increases with the increased riding exposure and decreases with age [6,11]. Furthermore, the MRBQ factors are strongly linked to personality theories like sensation seeking, aggression, the big five, and reinforcement sensitivity [12], as well as psychological models like the theory of planned behaviour (TPB), health belief model (HBM), and locus of control (LOC) [11]. Examining Individual differences in crash involvement are one of the most important uses of the MRBQ. However, given the findings, previous research appear to be inconsistent, it is still unclear how effectively the MRBQ can predict crash involvement. For example, many studies have found that traffic errors are the most common predictor of rider crash involvement [6,13–16], whereas Stephens et al. [17] and ÖZkan et al. [11] found that stunts are the main predictor. Furthermore, several researches asserted that speeding is a significant predictor [8,18]. Despite the fact that most research found a link between MRBQ factors and rider crash participation, Steg & Brussel [19] found that MRBQ factors do not significantly predict crash involvement.

Due to the sampling errors, the *p*-values and effect sizes are inconsistent between studies [20,21]. Therefore, the results of previous studies were inconsistent in nature. It shows the need of combined analysis of all the published results to understand the reason of inconsistency in results and to evaluate the predictability of MRBQ by aggregating the conclusion of studies which examined the relationship between MRBQ factors and crashes. However, as far as authors are aware, no such study has existed which performed the combined analysis on results of published studies. As a result, the present study performed a meta-analysis of the studies chosen as part of the review process. The primary benefit of meta-analysis over other review methods is that data are taken from numerous studies to improve evaluations of effects and power [22]. The primary research objective of the current study is to analysis the predictability of MRBQ in terms of crashes and the secondary objective is to evaluate the relationship between MRBQ factors and rider's demographic characteristics. Moreover, the present study also explain the future recommendations to improve the predictability of MRBQ.

The present study investigated the existing literature on the association between MRBQ factors and crash involvement in depth. The remaining part of the paper is organized as follows: the second section covers data and techniques, as well as the approach and criteria for finding and choosing papers for meta-analysis. The qualitative evaluation and meta-analysis results of chosen papers are presented in the third section. Finally, the concluding observations and research recommendations are presented in the final section.

## 2. Method

### 2.1. Search strategy and eligibility criteria

Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines [23] were used to perform a literature search to find published research on MRBQ. In the month of March 2022, a literature search was conducted. The searches were done with a mix of keywords in three databases: Google Scholar, PubMed, and Web of Science (see Fig. 1). Because the first MRBQ was a 2007 research [6], all three databases were subjected to a publication constraint of after and in year 2007. Full-text publications authored in English and

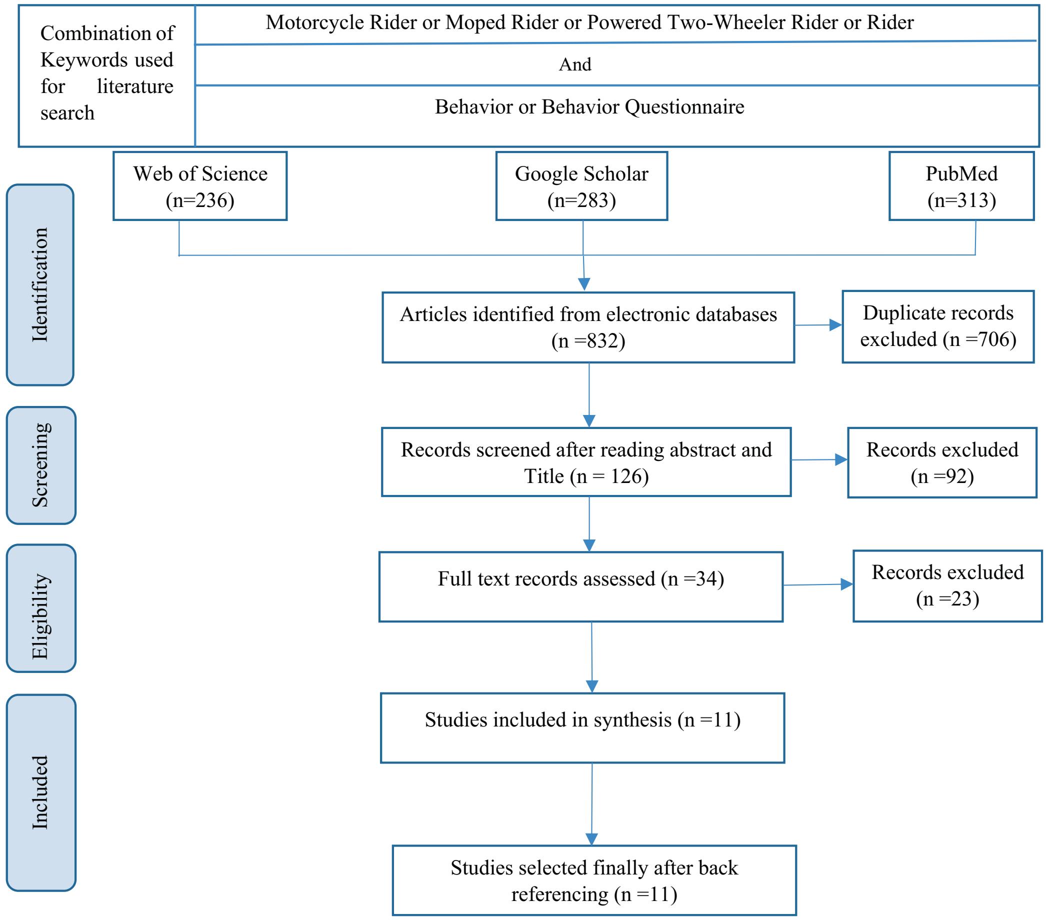


**Fig. 1.** Flow chart of the systematic literature review.

published in peer-reviewed journals and conferences were considered. Further, studies were required to examine the relationship between riding behaviour and crash involvement of Power-Two Wheeler (PTW) users using MRBQ. A PTW user is defined in this study as someone who rides a motorbike, moped, or scooter on the road. The current meta-analysis excluded articles that employed MRBQ but did not investigate the link between self-recorded crashes and MRBQ factors.

### *2.2. Screening and selection*

A total of 832 articles were found, with 126 remaining after duplicates were removed (see Fig. 1 for the screening and selection process). Studies had to (a) be peer-reviewed full-text studies available in the English language; (b) focus on analysing the relationship between self-reported crashes and riding behaviour; and (c) have used an original or modified version of MRBQ developed by Elliott et al. [6], to be considered for inclusion. The authors started with a title search of 126 articles, and 76 articles were eliminated based on the results. After reading the abstracts of the remaining 50 publications, the authors reviewed the abstracts and retrieved full-text articles for those that met the inclusion criteria. From 50 papers, 34 were chosen for full-text examination, while the rest were excluded. Finally, the authors reviewed full text publications using the purpose build checklist (see Appendix A).

11 publications were chosen for the current study out of 34 that were assessed using a checklist and met the inclusion criteria. Backward referencing was used to retrieve the cited papers in all 11 selected research, as recommended by Liberati et al. [24]. However, none of the referred papers (with the exception of 11 chosen research) met the inclusion requirements. As a result, 11 papers were chosen for the current systematic review and meta-analysis (see Table 1).

### *2.3. Data extraction*

The association between MRBQ factors (traffic error, control error, speed violation, stunt) and the five variables (age, gender, riding experience, riding distance, and self-reported crashes) was noted down for each study. Previous research used terms like odd ratio, regression coefficient, mean, and standard deviation to describe the effect size. As a result, the effect sizes reported by each study were transformed into a Pearson correlation coefficient using Borenstein et al. [26] calculations and Peterson and Brown's findings [27]. For each weighted mean, the null hypothesis test (z-values and related significance values) and 95% confidence interval (CI) were presented. The confidence interval was calculated using the Eq. (1).

$$CI = X \pm 1.96\, S.E \tag{1}$$

Where CI is the upper and lower confidence interval, X is the coefficient, and SE is the standard error.

### *2.4. Summary measures and synthesis of results*

To account for potential heterogeneity, a random-effect meta-analysis approach was employed to examine the link between MRBQ factors and self-reported crashes. The random-effect model is ideal for Meta-analysis for studies that exhibit consistent methodological

**Table 1**
Brief overview of studies included in systematic review.

| Author (s) | Country | Objective | Sample Type | Sample Size | Mean Age (Yr.) | Male Participants (%) | Main Results |
|---|---|---|---|---|---|---|---|
| [6] | United Kingdom | Develop a questionnaire for analysing motorcyclist's riding behaviour and observing relationship between crash risk and different type of behaviour. | General Rider Population | 8666 | 43 | 94 | Traffic errors were the risky riding behaviour and most significantly predicted crash risk. |
| [19] | Netherland | To examine the Reason behind the more number of accident of moped riders in Netherland. | Young Moped Riders | 146 | 17.3 | 40 | Errors, lapses, and Violation did not predict the crash involvement of riders. |
| [18] | Nigeria | To examine the factor structure of original MRBQ (Elliott et al., 2007) for Nigerian Rider population. | Commercial Motorcycle Riders | 500 | 27 | Not given | In Nigeria, performance of original MRBQ was different and exploratory analysis suggested four factor structure rather five. |
| [11] | Turkey | To examine the factor structure of original MRBQ (Elliott et al., 2007) for Turkish Rider population and observing relationship between MRBQ factors and self-reported crash | General Rider Population | 451 | 33.94 | 100 | Exploratory factor analysis produced 5-factor solution and regression analysis suggested that stunts are the main predictor of accidents. |
| [8] | Australia | To examine the psychometric properties and applicability of original MRBQ among Australian novice riders. | Australian novice riders | 1305 | 36 | 79.2 | Confirmatory factor analysis suggested that the previously explored factor structure (original MRBQ) did not fit for the Australian novice riders. Additionally, the insufficient inconsistency, stability, content and predictive validity were reported insufficient. |
| [17] | Australia | To determine the suitable factor structure of modified MRBQ and relationship between MRBQ factors and crash involvement. | General rider population | 470 | 44.78 (Calculated based on given data) | 89 | Stunts behaviour were found to be associated with crash involvement. |
| [16] | Vietnam | To investigate factor structure of MRBQ and examine which MRBQ factors are associated with self-reported crashes. | General rider population | 2254 | 24.3 | 27 | Exploratory factor analysis revealed a four-factor solution and regression analysis showed that traffic errors are the main predictor of crash involvement. |
| [14] | Australia | To understand the crash risk factors for novice motorcycle riders. | Novice motorcycle riders | 2399 | 35.7 | 80.7 | Errors and speeding were associated with crash involvement of riders. |
| [25] | India | To determine the suitable factor structure of modified MRBQ among young riders in Manipal, India and predictive validity of MRBQ factors. | Young Motorcycle Riders | 300 | 20.91 | 93 | Exploratory factor analysis revealed a five-factor solution and regression analysis showed that no significant relationship between MRBQ factors and crash involvement. |
| [15] | Colombia | To identify the relationship between MRBQ factors and self-reported crashes of motorcycle taxi riders. | Motorcycle taxi riders | 438 | 33.35 | 99.5 | Traffic errors are the main predictor of crash involvement. |
| [13] | India | To examine the factor structure for Indian version of MRBQ and risky riding behaviour of Indian riders. | General rider population | 392 | 25.34 | 79.08 | Traffic errors were the main predictor of crash involvement among all the MRBQ factors. |

differences as it assumes that true effect size varies across studies [26]. The random-effect model is represented by Eq. (2).

$$\theta_i = \mu + u_i \tag{2}$$

Where, $\theta_i$ Represents true effect. $u_i$, is the error term added for accounting heterogeneity and follows a normal distribution with mean u and variance $\tau^2$. The zero value of variance indicates that the true effects are homogeneous. In the present study, Q statistics for analysing variation between effect sizes across studies and $T^2$ for checking whether there is a systematic between-study variation in results were reported. A statistically significant Q value shows that possibly the true effect size differs crosswise studies and if there is significant unexplained variance in the true effects, then the value of $T^2$ will not be equal to zero [28]. Finally, $I^2$ statistic was also reported in the present study to compute the percentage of observed variance due to true variation in effect sizes.

### 2.5. Moderator analysis

To investigate, if the detected moderator may explain disparity in effect size, the study used meta-regression under the random-effects model. Other moderators, such as the type of riders included in the sample (i.e., professional riders, general population, young drivers), were considered categorical variables, whereas the gender composition (i.e., the proportion of male participants) and publication year of the study moderator were considered continuous variables. Separate dummy variables were coded for the discrete moderator, which contains more than two categories. The proportion of explained study between variance ($R^2$) was reported for the significant moderators, and the Q statistic was produced for all moderators with a variation in effect size.

### 2.6. Additional analysis

Three approaches were employed to check for publication bias: funnel plots, egger's regression test, and Duval S. and Tweedie R., [29] trim and fill procedure. A funnel plot is a method for displaying the results of exploratory meta-analyses. There is no publishing bias when research are presented symmetrically using a funnel plot for population effect size [30]. As funnel plot is a graphical measure, egger's test is a quantitative measure of publication bias, and if the $p$-value is <0.05, no publication bias exists [31]. To calculate adjusted effect sizes, the trim and fill process is employed [30]. All statistical analyses in the study were performed using the Comprehensive Meta-Analysis (CMA) 3.0 software, which came with a trial version.

## 3. Results

### 3.1. Characteristics of selected studies

The first eligible paper [6] was published in 2007, and the most recent was published in 2021 [13], spanning more than a decade of research on this issue. The geographical coverage is also extensive, as can be seen in Table 1, with articles reporting research conducted in the UK, Europe Oceania, West Africa, the Middle East, and South America. Furthermore, riders from the general public (k = 5), professional riders (k = 2), and young riders (k = 4) were all included in the experiments. The sample size ranged from 146 to 2399, with the majority of male participants (see Table 1), with the exception of two studies [16,19] having a higher percentage of female participants. Cross-sectional research was used in the majority of the studies. Because count data models are commonly employed in crash analysis research, the majority of the studies (k = 8) reported effect size as regression coefficient, two studies reported odd ratio, and only one study reported Pearson's correlation coefficient (r) out of the 11 studies reviewed.

Five MRBQ factors, i.e., “traffic error”, “control error”, “speed violation”, “stunts”, and “safety equipment use”, were identified from 11 selected studies. Some of the studies presented traffic error, and control Error factors as common factors, namely “error” [8,14,19], and these factors were explored in all the selected studies. Similarly, the “speed violation” factor was also reported by all the 11 studies, whereas stunt and safety equipment use factors were explored by 9 and 8 studies, respectively. In most of the studies, “traffic error” factor was reported as main predictor of self-reported crashes among all the MRBQ factors. When it comes to demographic characteristics of riders, effect of rider's age and riding experience on rider's crash involvement was commonly observed by researchers. Eight studies reported that rider's age is significantly affecting rider's crash involvement, whereas only four studies observed experience as a significant factor that affects the crash involvement of rider's. Overall, a lot of diversity regarding the association of demographic characteristics and MRBQ factors with self-reported crashes is measured in the riding behaviour research literature.

### 3.2. Meta-analysis results

Individual meta-analyses were conducted on the relationship between crashes and each MRBQ factor and demographic variables such as age and experience. Table 2 shows an overview of the meta-analysis findings. The relationship between traffic error and self-reported crashes was insignificant ($r = 0.239$, 95% CI [−0.17, 0.578], $p = 0.250$). The true effect sizes have a considerable unexplained variance, according to Q statistics (Q (11) = 5849.62, p0.001). Furthermore, real variation of effects accounts for nearly 100% of the observed variance (I2 = 99.83%). Similarly, the relationships between other MRBQ factors and self-reported crashes were insignificant, with the exception of the speed violation factor, which was significant but weaker ($r = 0.135$, 95% CI [0.063, 0.152], p0.001). Except in the case of speed violation, Q statistics revealed that all correlations were again heterogeneous, and $I^2$ values for all relations revealed that >90% of the observed variation replicates actual changes across studies (see Table 2).

According to the meta-analysis of relationship between rider demographics and crashes, there is a significant relationship between self-reported crashes, age ($r = 0.06$, 95% CI [−0.09, 0.20], p0.001) and riding experience ($r = -0.4$, 95% CI [−0.84, 0.37], p0.001). Table 2 shows that the link between crashes and age or riding experience produced similar findings in terms of Q statistics and $I^2$ value. The forest plots in (Figs. 2 to 8) show an overview of the impacts from each of the included studies for all categories of variables.

**Table 2**
Summary of random-effects meta-analysis results.

| Predictors | Number of studies (k) | Polled effect size | 95% CI | Q statistic | $I^2$ |
|---|---|---|---|---|---|
| MRBQ Factors | | | | | |
| Traffic Error | 11 | 0.24 | (−0.17,0.57) | 5849.62 | 99.83 |
| Control Error | 11 | −0.04 | (−0.20,0.12) | 875.48 | 98.86 |
| Stunts | 9 | 0.06 | (−0.04,0.16) | 189.63 | 95.78 |
| Speed Violation | 11 | 0.11* | (0.06,0.15) | 57.914 | 82.73 |
| Safety Equipment use | 8 | −0.03 | (−0.15,0.09) | 191.23 | 96.34 |
| Demographic Characteristics | | | | | |
| Age | 8 | 0.06* | (−0.09,0.20) | 279.75 | 97.50 |
| Riding Experience | 4 | −0.40* | (−0.84,0.37) | 1356.48 | 99.78 |

### 3.3. Moderator analysis

The necessity to assess possible modifiers derives from the heterogeneity of study effects. As a result, the present study used a moderator analysis to identify the moderators. The meta-regression results for presumed moderators (as explained in section 2.5) suggested that there are no significant covariates for any of the focal relations (i.e., the relation between MRBQ factor and self-reported crashes), except the rider type covariate (See Table 3). The effect on general population riders was not significant for any of the focal relations as compared to professional riders. Even though the type of rider explained a 31% variance in true effect size in the case of speed violation-crashes correlation, there still remained significant unexplained differences between studies (Q = 8.04, $p < 0.5$).

### 3.4. Publication bias

In the case of “traffic error”, the funnel plot seems to be asymmetric, with the major number of study effects lying to the left of the mean (see Appendix B). Additionally, Egger's test showed statistical significant result (intercept = −27.85, $p = 0.02$), and Duval and Tweedie trim and fill procedure assigned none of the studies to the left of the mean. The adjusted effect was $r = 0.602$, 95% CI [0.59, 0.61], which is exactly similar to observed value. Similarly, the visual inspection of funnel plots appeared to be asymmetric for other focal correlations, except in the case of safety equipment use-crashes correlation in which the funnel plot was symmetric. Table 4 represents the results of Egger's test and Duval and Tweedie trim and fill procedure for all the focal correlations.

## 4. Discussion

The primary objective of this meta-analysis was to examine the predictability of MRBQ by observing the association of self-reported crashes with MRBQ factors. Additionally, the relation between rider's demographic characteristics and crashes was analized. The major findings of the study demonstrated that except for the speed violation factor, all of the predictors (i.e., MRBQ factors) had no significant relationship with crashes. Moreover, age and riding experience were major predictors of crashes when it came to demographic factors. Age, on the other hand, exhibited a poor relationship with crashes, whereas riding experience had a moderate relationship with crashes. The sole significant moderator was rider type; particularly, for professional riders, the association between all predictors and crashes was significant.

### 4.1. Meta-analysis

According to the meta-analysis, only the speed violation factor exhibited a significant correlation with crashes that too was a weak correlation, indicating the lower predictability of MRBQ factors in terms of crashes. This is consistent with the findings of some authors [8,19], who have also questioned the MRBQ predictability. Although several constraints, such as a limited number of studies available on this topic, heterogeneity in effect sizes, measurement error in the computation of

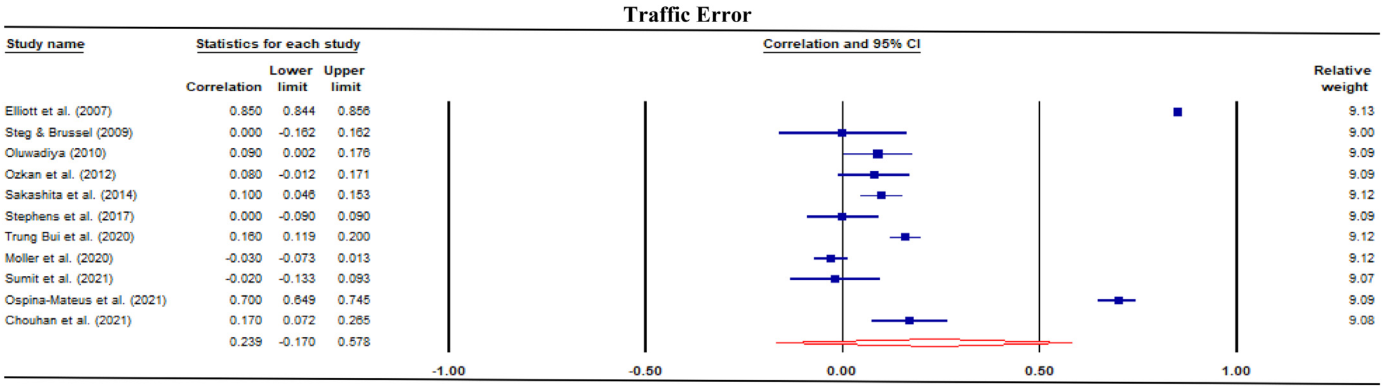


**Fig. 2.** Standardized effect and forest plots for the sample of studies regarding traffic error.

effect sizes, self-reporting biases, and publication biases, may affect the results of meta-analysis. The limitation of a small number of studies becomes more problematic if effect sizes are highly heterogeneous, as they are in the present study. Three moderators were used to try and explain the heterogeneity in effect sizes in this study, but only one moderator (rider type) produced significant results, implying that other factors are to account for effect size variability. The presence of measurement error in research data resulted in differences between observed effect size and computed effect size. Three errors, namely random response error, transient error, and specific factor error, must be taken into account when determining true effect sizes [32]. As the MRBQ factors are drawn using the factor analysis method, specific error can be neglected. Additionally, responses for the MRBQ can be collected for two different time periods in order to account for random response errors and transient error. However, there is no study utilizing MRBQ that has collected the response on two occasions in the literature. Many researchers have however used two measurements separated by a time period in the case of DBQ [33,34]. As a result, it is recommended that further research be done to better understand MRBQ predictability. Because the results of MRBQ research are based on self-reported data, they may be influenced by biases such as overestimation of one's own skills [35] and social desirability [36]. To address this issue, objective criteria such as rider speed under naturalistic situations, gap acceptance behaviour, lane changing behaviour, and other variables that may serve as an alternate variable of crashes should be used instead of self-reported crashes.

The results of the meta-analysis on the relationship between age and crashes revealed that older riders are more vulnerable and have more crashes than younger riders. Furthermore, the results of a meta-analysis of the relationship between riding experience and crashes found that inexperienced riders are more likely to be involved in crashes than experienced riders. These findings are counterintuitive because older riders will have greater experience, but the results demonstrate that older riders are more likely to be involved in crashes than experienced riders.

### 4.2. Study implications

The implications of this meta-analysis lie in providing a thorough understanding of the overall quantitative relationship of MRBQ factors for the self-reported crashes of the rider. This study provided a focused and quantitative analysis of which specific MRBQ factor is the most and least impactful. Moreover, this meta-analysis observed that the relationship of MRBQ factors with crashes differed by type of riders included in the study. These differential effects might be because of the essential impact of social elements and measurement issues on the effect of the MRBQ factor and self-reported crashes. Furthermore, because the study focused on the predictive validity of MRBQ in relation to crashes, it provides a reference for additional MRBQ implications (e.g., relationship with psychological measures) to further investigate MRBQ's applicability. It also provides a solid foundation for stimulating applied study into the relationship between riding behaviour and crashes. The inferences of the present meta-analysis also provide a way forward for researchers to enhance the predictive ability of MRBQ. Moreover, results of the present study also guide the policy makers to give recommendations that can be helpful in reducing motorcycle crashes. Policy makers may include the recommendation that the over-speeding should be heavily penalized for the riders who

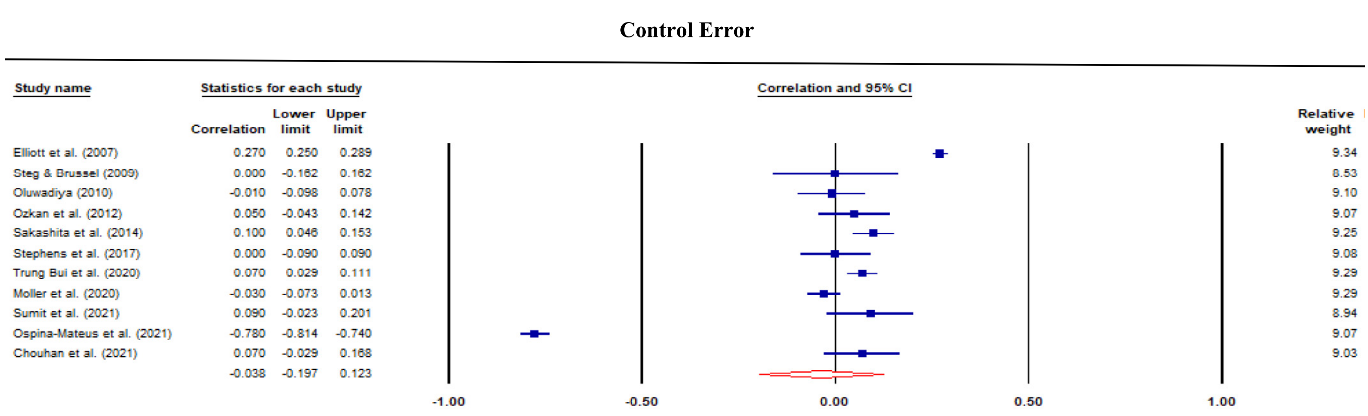


**Fig. 3.** Standardized effect and forest plots for the sample of studies regarding control error.

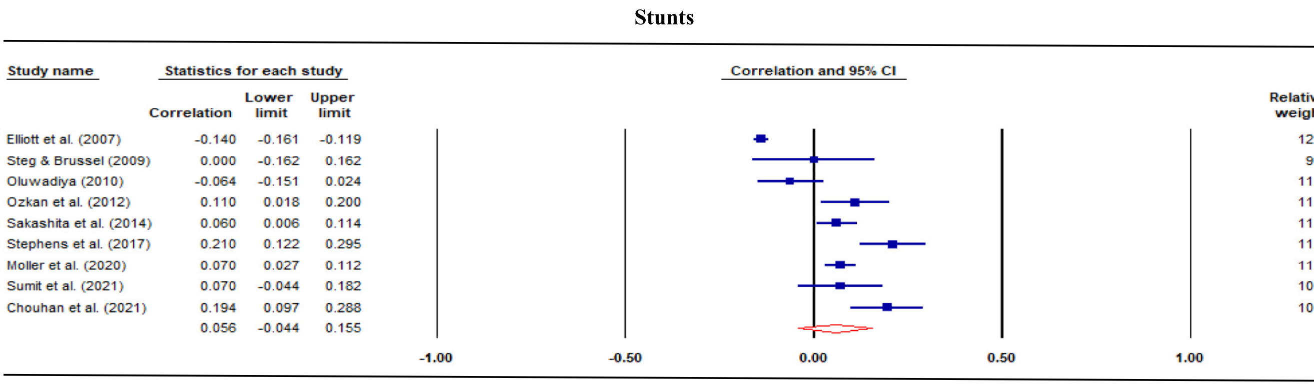


**Fig. 4.** Standardized effect and forest plots for the sample of studies regarding stunts.

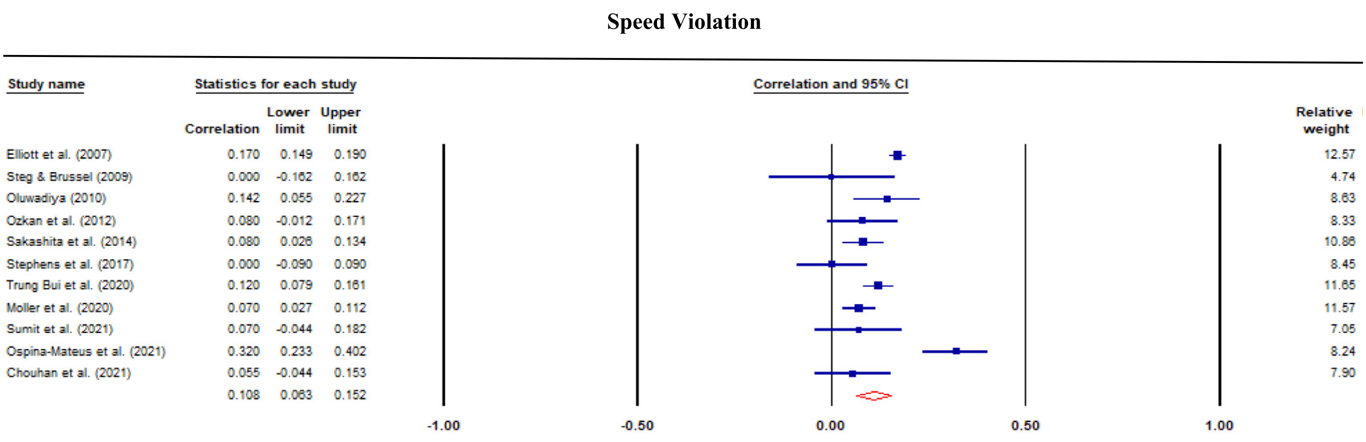


**Fig. 5.** Standardized effect and forest plots for the sample of studies regarding speed violation.

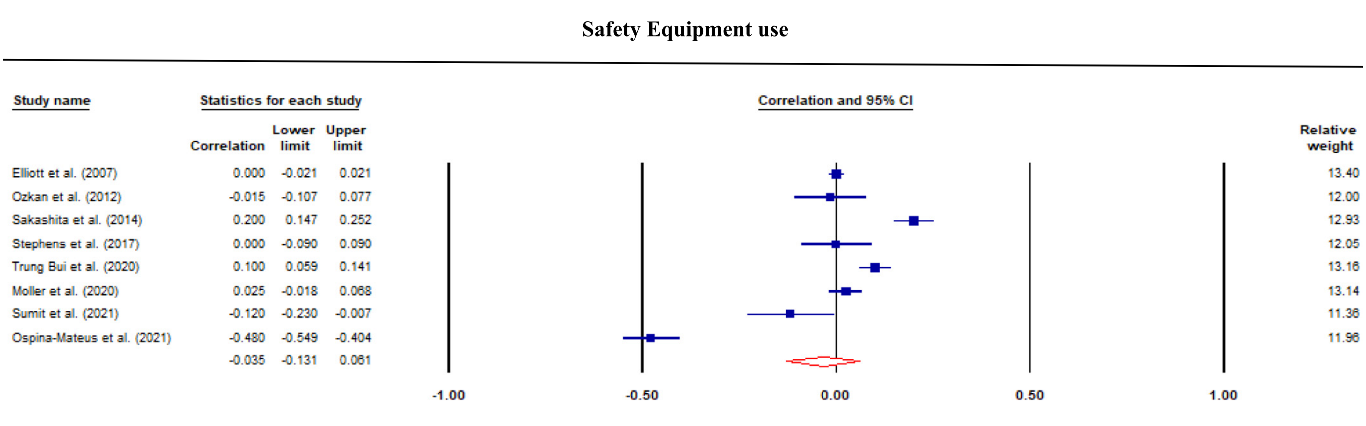


**Fig. 6.** Standardized effect and forest plots for the sample of studies regarding safety equipment use.

performed speed violation behaviour and their license may be rejected if it is performed more than a certain number of times. Additionally, policies related to rider's age should also be incorporated in the existing policies as the older riders are more vulnerable and have more crashes than younger riders. It has been concluded in the literature that older drivers who have a medical condition are more vulnerable [37].Therefore, it is recommended that medical fitness certificate should be mandatory for the riders and it should be renewed after a fixed interval of time.

## 5. Conclusions and recommendations

A decade after the influential study of Elliott et al. [6], the MRBQ has gained vast acceptance. The present meta-analysis combined the available literature and revealed that only the speed violation factor significantly predicts self-reported crashes. The correlation between the speed violation and self-reported crashes approximates 0.11. Further, the meta-analysis on the relationship between demographic characteristics and crashes showed that age and riding experience are significant

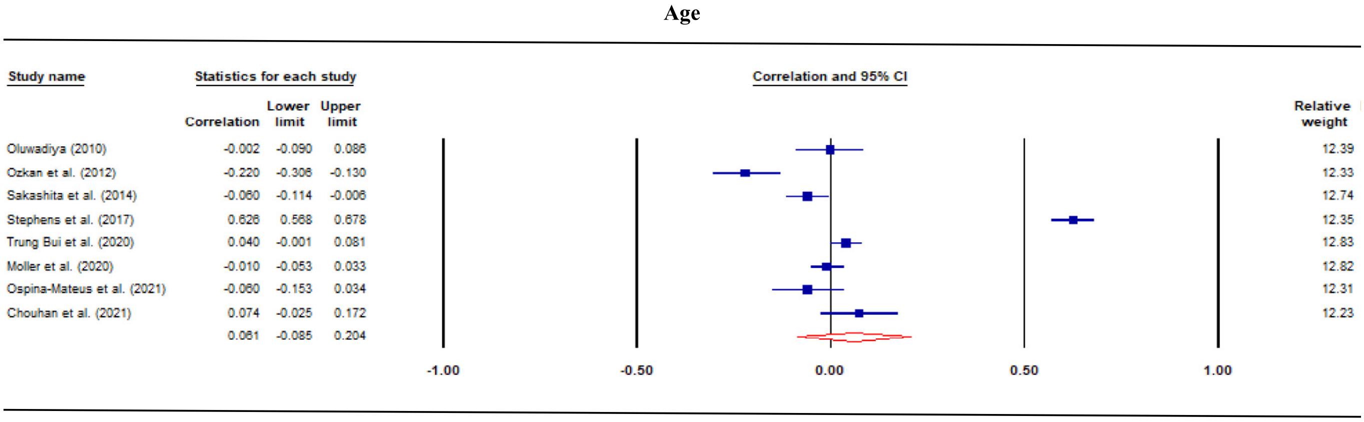


**Fig. 7.** Standardized effect and forest plots for the sample of studies regarding age.

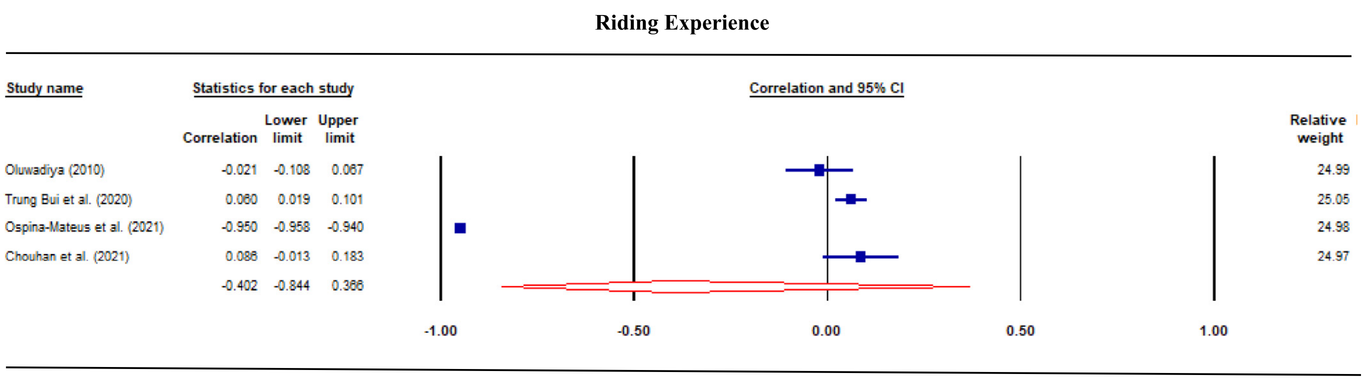


**Fig. 8.** Standardized effect and forest plots for the sample of studies regarding riding experience.

**Table 3**
Test of significance for the meta-regression models regarding each moderator.

| Moderator | Traffic Error | | | | Control Error | | | | Stunt | | | | Speed Violation | | | | Safety Equipment use | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | k | Q | df | p | k | Q | df | p | k | Q | df | p | k | Q | df | p | k | Q | df | p |
| Publication Year | 11 | 0.59 | 1 | 0.4410 | 11 | 2.71 | 1 | 0.0999 | 9 | 8.52 | 1 | 0.0035 | 11 | 0 | 1 | 0.9666 | 8 | 1.29 | 1 | 0.2565 |
| Rider Type | 11 | 0.99 | 2 | 0.6104 | 11 | 12.49 | 2 | 0.0019 | 9 | 0.7 | 2 | 0.7057 | 11 | 8.04 | 2 | 0.0179 | 8 | 28.81 | 2 | 0.00 |
| % of Male Participants | 11 | 0.28 | 1 | 0.5967 | 11 | 0.57 | 1 | 0.4515 | 9 | 0.02 | 1 | 0.8819 | 11 | 0.80 | 1 | 0.3698 | 8 | 3.03 | 1 | 0.0819 |

**Table 4**
Summary of publication bias tests.

| MRBQ Factor | Funnel plot symmetry | Egger's Test | Duval and Tweedie trim and fill procedure |
|---|---|---|---|
| Traffic Error | Asymmetric | $r = -27.85$, $p = 0.02$ | 0 studies to left of mean |
| Control Error | Asymmetric | $r = -9.69$, $p = 0.04$ | 4 studies to left of mean |
| Stunts | Asymmetric | $r = 5.89$, $p = 0.01$ | 1 studies to left of mean |
| Speed Violation | Asymmetric | $r = -1.87$, $p = 0.15$ | 0 studies to left of mean |
| Safety Equipment use | symmetric | $r = -2.34$, $p = 0.54$ | 1 studies to left of mean |

predictors. Some limitations that may affect the meta-analysis results are discussed, including a limited number of studies available on this particular topic, heterogeneity in effect sizes, measurement error in the calculation of effect sizes, biases in self-reporting, and publication biases. This study accurately analyzed the overall MRBQ-crashes relationship in a total sample of >17,000 participants. Different research designs are now suggested for increasing the ability of MRBQ to predict crashes. Specially, it is recommended to use large-sample validation studies with recorded crashes or alternate variables for crashes as a criterion, such as driving simulator performance or riding information using field data. Though only large sample studies may not be solution of the inconsistency in the results, therefore, it is recommended that future research should focus on the resolving the problems regarding under reporting of crash data and unbalancing of crash data using alternate variables for crashes as a criterion, such as surrogate safety measures indicator or making the sustainable accident recording systems. The other reason, for inconsistency in the results, may be the social and cultural differences all over the world. Therefore, it is recommended that the future research should also include the factors related to differences in riding behaviour, vehicle characteristics, road and its environment, speed regulation and law enforcement and safety cultures all over the world. Further, it is recommended that items related to distraction, such as mobile phone use, drinking driving, listening music, etc., should be included in MRBQ, which is presently ignored.

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## Declaration of Competing Interest

No potential conflict of interest was reported by the authors.

## Appendix A. Full-text data extraction sheet

Title:
Author:
Year:
Country:
Publication language:
Publication type (e.g., full-text peer-reviewed journal paper):
Study aims/objectives/hypotheses:
Participant details (e.g., number, age, gender):
Inclusion/exclusion criteria:
Definition of AV:
Acceptance measures:
Other measures:
Analysis:
Results:
Other comments

## Appendix B. Funnel plots for all the focal correlations


**Fig. B.1.** Publication bias funnel plot for the study regarding traffic error-crashes relation.

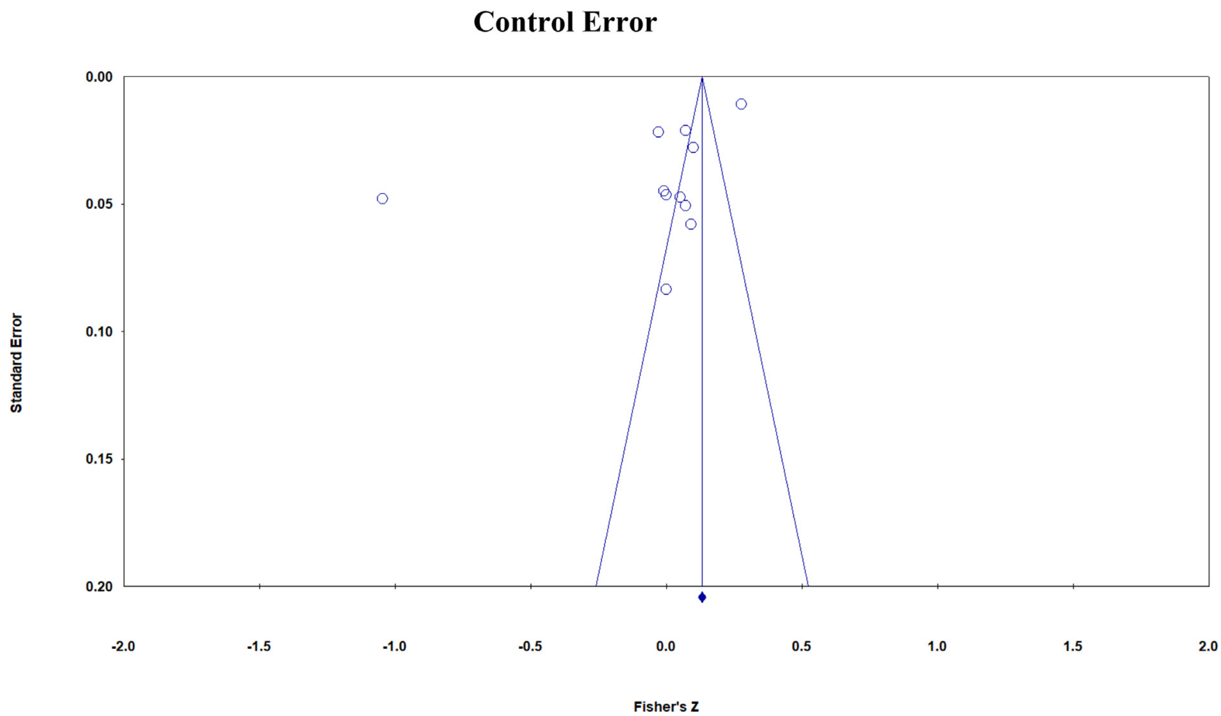


**Fig. B.2.** Publication bias funnel plot for the study regarding control error-crashes relation.

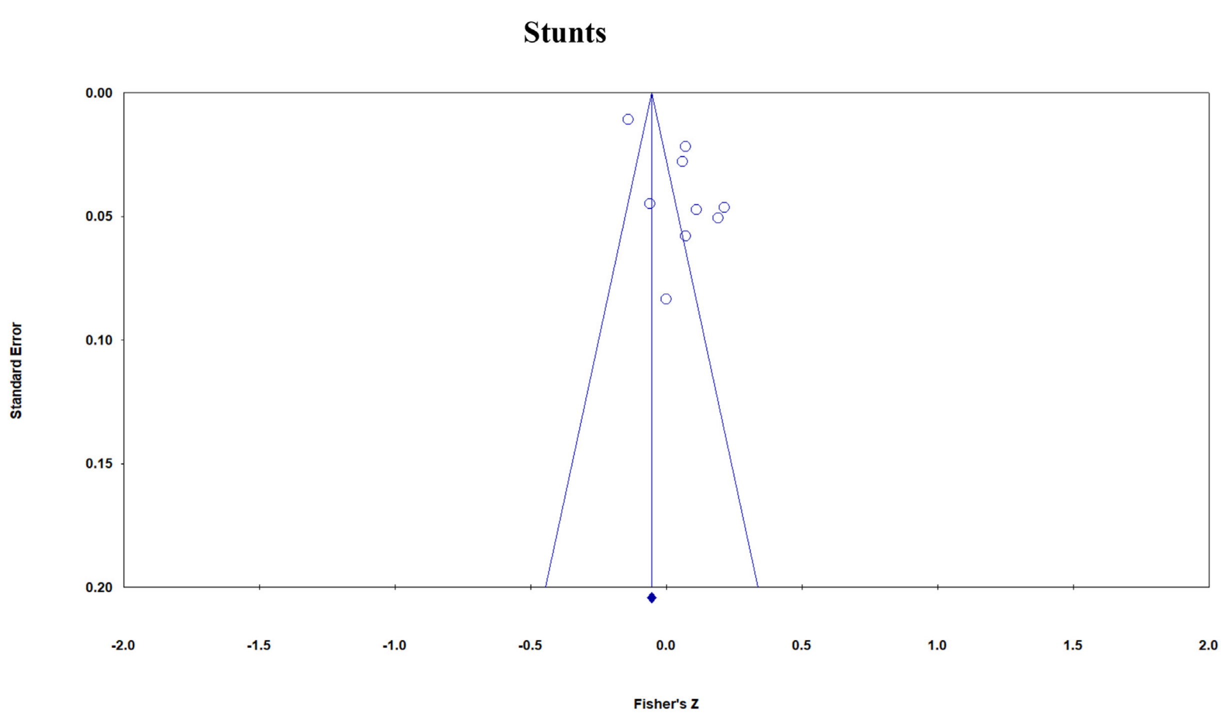


**Fig. B.3.** Publication bias funnel plot for the study regarding stunts-crashes relation.

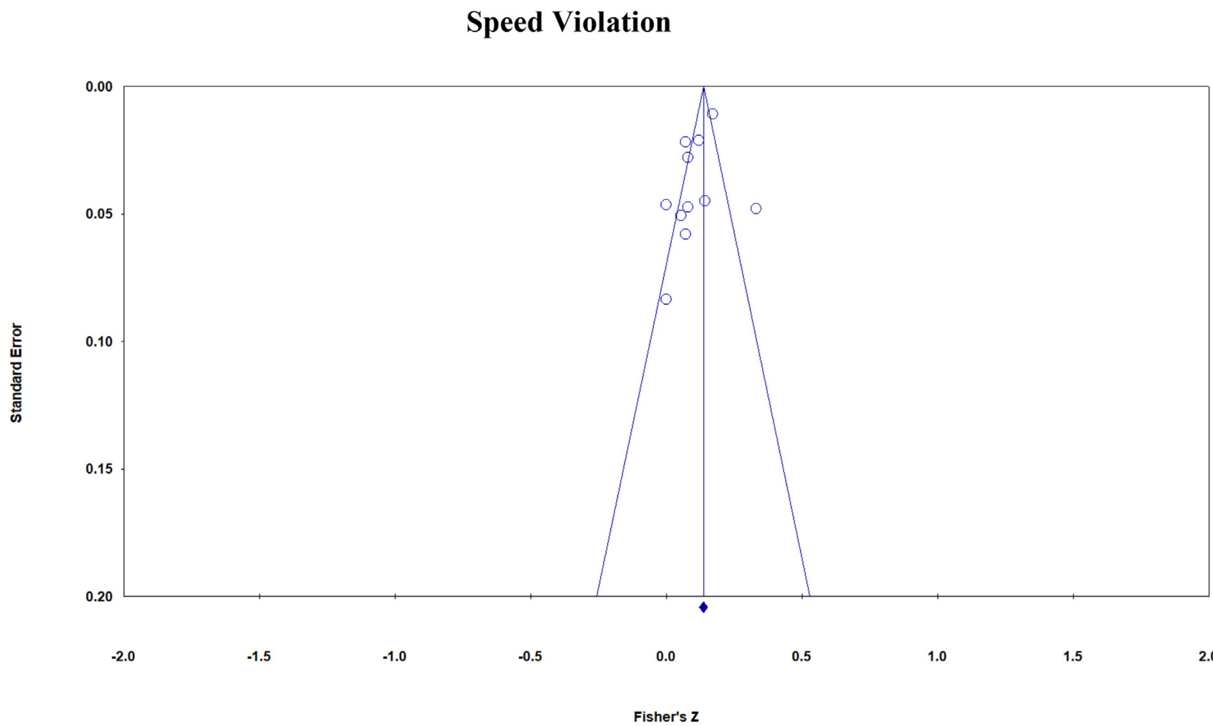


**Fig. B.4.** Publication bias funnel plot for the study regarding speed violation-crashes relation.

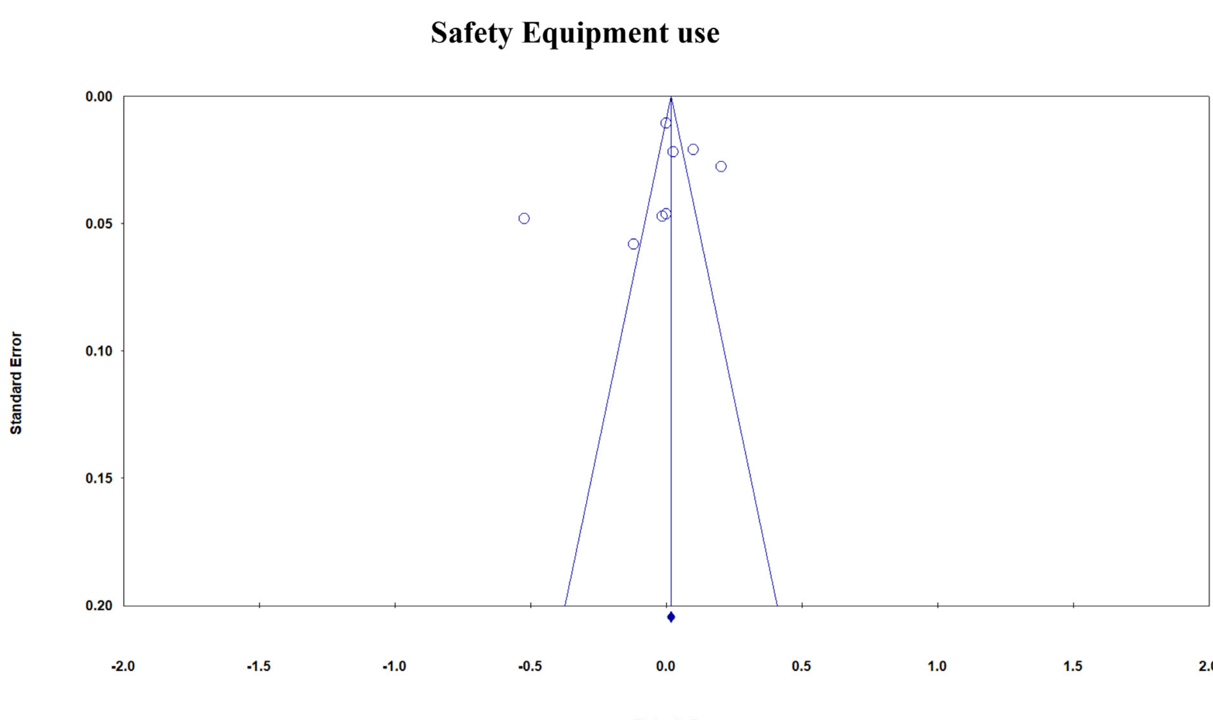


**Fig. B.5.** Publication bias funnel plot for the study regarding safety equipment use-crashes relation.

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