National Journal of Physiology, Pharmacy and Pharmacology

RESEARCH ARTICLE

# Effect of helmet use on visual and auditory reaction time and peripheral field of vision

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**Received:** January 14, 2018; **Accepted:** February 06, 2019

## ABSTRACT

**Background:** In many Asian countries, motorcycles are an important means of transportation. The effectivity of helmets in reducing head injuries is studied, but the effect of helmets on the auditory and visual reaction time and peripheral field of vision of riders is of great concern. Moreover, the Indian markets are providing a large range of substandard helmets. Hence, the present study was designed to assess the effect of standard and substandard helmets on vision and hearing. **Aims and Objectives:** The aim of the study was to assess the following parameters - auditory reaction time, visual reaction time and peripheral field of vision without helmet, with standard helmet, and with substandard helmet and compare the same statistically**. Materials and Methods:** This comparative study was done in 57 subjects of the age group 18–25 years. The auditory and visual reaction time and peripheral field of vision were noted. A well informed written consent was taken from all the subjects. The statistical analysis was done by analysis of variance test and Paired "*t*"- test. **Results:** The helmet (standard and substandard) does not cause any significant change in visual reaction time and auditory reaction time for low-frequency sound as compared to without helmet. The auditory reaction time for high-frequency sound was significantly reduced in the substandard helmet. The field of vision is significantly decreased by the helmets in all four directions. **Conclusion:** A quiet, lighter, full-face helmet with minimum restriction of the field of vision should be redesigned. The use of substandard helmets should be discouraged.

**KEY WORDS:** Auditory Reaction Time; Helmet; Visual Reaction Time; Peripheral Field of Vision

## INTRODUCTION

In many Asian countries, motorcycles are an important means of transportation.[1] The riders of two-wheelers are at an increased risk of fatal accidents than a four-wheeler driver.[2]

Head injuries are the most severe and disabling injuries resulting from road traffic accidents.[3] The National Center for Statistics and Analysis of National Highway Traffic Safety Administration has estimated that helmets are effective in preventing fatalities by 37%.[4] Hence, there are stringent rules set up by the road traffic office regarding the use of helmets while riding a motorbike.[2]

The helmets are specifically designed with cushion effect to minimize the impact to the head to prevent injury at the site of impact and inertial injury at the sites away from the impact. Thus, a helmet provides an excellent full coverage protection to prevent head injury.[3]

The effectivity of helmets in reducing head injuries is studied but the effect of helmets on the auditory and visual reaction time and peripheral field of vision of riders is of great concern. Moreover, the Indian markets are providing

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| **Website:** www.njppp.com | Quick Response code |
| **DOI:** 10.5455/njppp.2019.9.0103006022019 | |

a large range of substandard helmets at a lower cost which lure the riders from low socioeconomic strata of the society. These helmets are not only substandard in providing safety but also their effect on auditory and visual reaction time, and peripheral field of vision is much more questionable.

Hence, the present study was designed to assess and compare - the auditory reaction time, the visual reaction time and peripheral field of vision in apparently young and healthy individuals first without a helmet and then with standard company patented ergonomically designed helmets and then also with substandard helmets.

### Aim

The aim of the study was to assess the effect of the helmet on auditory and visual reaction time and peripheral field of vision.

### Objectives

The objectives of the study were to assess the following parameters - auditory reaction time, visual reaction time, and peripheral field of vision without helmet, with standard helmet, and with substandard helmet and compare the same statistically.

## MATERIALS AND METHODS

The present comparative study was done in 57 subjects of the age group 18–25 years in the department of physiology. The mean of the body mass index of the subjects was 21.406 ± 3.39 Kg/m$^2$. The ethical committee clearance was taken.

### Inclusion Criteria

Young healthy individuals - 18–25 years of age were included in the study.

### Exclusion criteria

The following criteria were excluded from the study:
1. History of glaucoma, cataract.
2. History of any range or type of deafness.
3. Acute or chronic eye or ear infections.
4. Congenital anomalies.
5. History of any respiratory, cardiovascular, endocrinological, or neurological diseases.
6. History of diabetes, hypertension, or any other chronic illness.
7. Athletes.
8. Professional drivers.

Full face helmets were used as this type of helmets is proved to provide the best protection to the riders.[2]
- Standard helmet - helmet with ISI - 4151mark
- Substandard helmets - sold on the roadside, made of plastic, fiber, and other cheap materials.
- Auditory and visual reaction time was done by an instrument designed by INCO. Three readings each was taken, and the least of the reading was noted for both low- and high-frequency sound for auditory reaction time and red and green light for visual reaction time. Every stimulus was given after a time interval of 1 min.
- Peripheral field of vision was charted using Lister's perimeter.

A well informed written consent was taken from all the subjects after explaining the study and the procedure in detail.

The statistical analysis of the readings was performed by analysis of variance test. The significant observations were analyzed in groups of two by Paired *t* – test.

## RESULTS

Table 1 - The helmet (standard and substandard) does not cause any significant change in visual reaction time for green and red light as compared to without helmet.

Tables 2 and 3 - The use of standard or substandard helmet did not change the auditory reaction time for low-frequency sound significantly. The auditory reaction time for high-frequency sound was significantly reduced in substandard helmet as compared to standard helmet and without a helmet.

**Table 1:** Visual reaction time (analysis of variance)

| Determinants | Mean (secs)±SD | F | *P* value | Significance |
|---|---|---|---|---|
| Red light | | | | |
| Without helmet | 0.2495±0.101 | 2.9469 | 0.06 | Not significant |
| Standard helmet | 0.2526±0.1132 | | | |
| Substandard helmet | 0.2264±0.1132 | | | |
| Greenlight | | | | |
| Without helmet | 0.2492±0.0988 | 0.19517 | 0.822 | Not significant |
| Standard helmet | 0.2551±0.0993 | | | |
| Substandard helmet | 0.2587±0.1129 | | | |

**Table 2:** Auditory reaction time - analysis of variance

| Determinants | Mean (sec)±SD | F | *P* value | Significance |
|---|---|---|---|---|
| Low-frequency | | | | |
| Without helmet | 0.2819±0.1127 | 1.20321 | 0.304 | Not significant |
| Standard helmet | 0.2711±0.143 | | | |
| Substandard helmet | 0.2597±0.1423 | | | |
| High-frequency | | | | |
| Without helmet | 0.3255±0.1297 | 3.9577 | 0.02 | Significant |
| Standard helmet | 0.3139±0.1187 | | | |
| Substandard helmet | 0.2877±0.1223 | | | |

SD: Standard deviation

**Table 3:** Auditory reaction time - high-frequency (Paried *t*-test)

| I | II | *P* | Significance |
|---|---|---|---|
| Without helmet | Standard helmet | 0.38414 | Not significant |
| Standard helmet | Sub–standard helmet | 0.02663 | Significant |
| Without helmet | Sub–standard helmet | 0.02302 | Significant |

Tables 4 and 5 - The field of vision is significantly decreased by the helmets (standard and substandard) in all four directions right temporal, left temporal, and up and down as compared to without helmet. The peripheral field of vision is significantly more in an upward and downward direction in substandard helmet as compared to the standard helmet. In the right temporal and left temporal directions, the restriction of the field of vision produced by both the helmets does not statistically vary.

## DISCUSSION

Tables 1-3 show that wearing a helmet (standard or sub-standard) does not cause any significant effect on the visual reaction time for red or green light as well as on auditory reaction time for low-frequency sounds. However, a significant difference was noted in auditory reaction time for high-frequency sound on use of helmets. The auditory reaction time for high-frequency sounds was significantly reduced in substandard helmet as compared to standard helmet and without a helmet, whereas the use of standard helmet did not cause any significant difference in the auditory reaction time for high-frequency sounds as compared to without helmet.

In a similar pilot study by Abbupillai *et al*., they found that the auditory and visual reaction time was not affected in healthy male and female helmet users.[2]

Wu and Yang studied the significance of the weight of the helmet on the reaction time of 12 subjects. They concluded that as the weight of the helmet increases the reaction time increases. For per 100 gm increase in helmet weight the visual reaction time increases by 2% and auditory reaction time increases by 3%. In the present study, the weight of the standard helmet used was 1.224 kg, and substandard helmet was 0.977 kg.[5]

Whereas Kennedy *et al*. and Młyński *et al*., in two separate studies, concluded that the helmets show no protection against external noise with frequency range of <250 Hz, whereas the high-frequency sounds of >500 Hz are attenuated due to the action of spectral filters.[6,7]

In the present study, the standard helmet did not show any significant change in auditory reaction time for low- as well as high-frequency, but the use of substandard helmet caused decrease in auditory reaction time for high-frequency sounds which makes these helmets more noisy.

Hearing is an early warning system which helps swiftly redirect our vision and attention toward the source of the sound. A rider is exposed to not only engine noise but also wind turbulence noise and honking of other vehicles.[8] A noisy helmet will lead to more distractions and confusion of the rider. Whereas the quiet, standard helmet does not affect the ability of subjects to perceive an audible signal and provides protection against noise-induced hearing loss, a long-term complication in riders.

Tables 4 and 5 show that the use of standard and substandard helmet significantly reduces the field of vision in all the four directions (right temporal, left temporal, and up and down). The field of vision downward and upward is more significantly reduced in the standard helmet as compared to substandard helmet.

The main role of a helmet is to provide maximum protection against head injuries. A helmet reduces the damage to the head by cushioning the impact and bringing the head to a stop in a gradual manner. A full face helmet is considered to be a better performance helmet as it gives maximum coverage to the entire head and presence of a chin bar also protects against jaw injuries.[1] A standard helmet consist of a hard shell of fiberglass or thermoplastic to reduce the force of impact, an energy-absorbing foam lining to dissipate deceleration forces and a retention system of chin strap to stabilize the head, thus providing complete protection but the peripheral field of vision is sacrificed. This results in a greater degree of head rotation by the riders for visual detection or failure to detect the overtaking or nearby vehicles in the other lane

**Table 4:** Peripheral field of vision (Analysis of variance)

| Determinants | Mean (Degree)±SD | F | *P* value | Significance |
|---|---|---|---|---|
| Right temporal | | | | |
| Without helmet | 75.0526±4.168 | 7.3908 | 0.000966 | Significant |
| Standard helmet | 73.4737±4.9609 | | | |
| Substandard helmet | 73.3509±4.3609 | | | |
| Left temporal | | | | |
| Without helmet | 78.7368±4.3815 | 10.821 | 0.0005 | Significant |
| Standard helmet | 76.614±5.3008 | | | |
| Substandard helmet | 77.2281±5.134 | | | |
| Up | | | | |
| Without helmet | 50.5789±10.087 | 43.990 | <0.00001 | Significant |
| Standard helmet | 34.7193±11.4701 | | | |
| Substandard helmet | 40.9825±12.1118 | | | |
| Down | | | | |
| Without helmet | 63.7544±7.4888 | 87.666 | <0.00001 | Significant |
| Standard helmet | 43.5439±10.1014 | | | |
| Substandard helmet | 48.1228±10.3494 | | | |

SD: Standard deviation

**Table 5:** Peripheral field of vision (Paired *t*-test)

| Field of vision | I | II | *P*-value | Significance |
|---|---|---|---|---|
| Right temporal | Without helmet | Standard helmet | 0.00088 | Significant |
| | Standard helmet | Substandard helmet | 0.64333 | Not significant |
| | Without helmet | Substandard helmet | 0.00027 | Significant |
| | Without helmet | Standard Helmet | 0.00004 | Significant |
| Left temporal | Standard helmet | Substandard helmet | 0.22327 | Not significant |
| | Without helmet | Substandard helmet | 0.00085 | Significant |
| | Without helmet | Standard helmet | 0.00001 | Significant |
| Down | Standard helmet | Substandard helmet | 0.00122 | Significant |
| | Without helmet | Substandard helmet | 0.00001 | Significant |
| | Without helmet | Standard helmet | 0.00001 | Significant |
| Up | Standard helmet | Substandard helmet | 0.00058 | Significant |
| | Without helmet | Substandard helmet | 0.0001 | Significant |

resulting into crash accidents. However, a standard helmet in case of an accident will remain buckled and sustain a force of 150 kg while a substandard helmet just supports a load of 5 kg and unbuckles easily leading to fatal injuries than protection.[9] Although it provides a better field of vision upward and downward as compared to a standard helmet, the protection is severely compromised.

Limitations - the present study was done in stationary position, a better insight will be obtained if done while actually riding a motorbike.

## CONCLUSION

The visual reaction time for red and green light and auditory reaction time for low-frequency sound are not significantly changed by the use of helmets. The auditory reaction time for high-frequency sound is significantly reduced in substandard helmets as compared to standard helmet and without a helmet due to lack of attenuation of high-frequency sounds, making it more noisy and distracting. The peripheral field of vision is significantly reduced in right temporal, left temporal, upward and downward directions by use of helmets. The substandard helmet provides a significantly better field of vision in an upward and downward direction as compared to standard helmets at the cost of the protection of the rider. Hence a quiet, lighter full face helmet with minimum restriction of the field of vision should be redesigned. Provisions should be made to reduce the cost of standard helmets to prevent the use of substandard helmets as it completely fails to serve the purpose of protection of the rider.

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**How to cite this article:** Joshi PK, Kaur M, Choity M. Effect of helmet use on visual and auditory reaction time and peripheral field of vision. Natl J Physiol Pharm Pharmacol 2019;9(4):307-311.

**Source of Support:** Nil, **Conflict of Interest:** None declared.