原　　著

Effects of Face Guard Design in Contact & Collision Sports on Static and Kinetic Visual Acuity

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〔**Abstract**〕 A face guard (FG) is a kind of face protection equipment for contact & collision sports. Although various kinds of FGs are used, they are generally classified into two types depending on the presence or absence of a vertical bar between the eyes. FGs with a bar are more useful for face protection, but could obstruct the visual field to some extent. The purpose of this study was to evaluate the effects of differences in FG configurations on static and kinetic visual function.

Static visual acuity (SVA), kinetic visual acuity (KVA) and their correlation coefficients of 10 college athletes were evaluated using a motion visual acuity tester (AS-4F, Kowa), under three conditions: group A, with no FGs (the naked eye); group B, with FG without a vertical bar between the eyes; and group C, with FG with a bar.

In the results, there was no significant difference in SVA and KVA (LogMAR) among the three conditions, and the correlation coefficients (Pearson) between SVA and KVA in A, B, and C were 0.517, 0.588, and 0.321, respectively. Although it is generally suggested that there is a strong correlation between SVA and KVA, the correlation in C was weak, suggesting that FG with a vertical bar between the eyes could lead to a variation in SVA and KVA for some athletes.

Introduction

Face guards (FGs) are used for facial protection in contact & collision sports such as American football, ice hockey, lacrosse, etc. due to their high incidence of injuries[1~3] (**Figure 1**). Various improvements have been made to FGs used for these sports since early times, and various kinds and types are now available. FG configurations can generally be classified into two types: one with a vertical bar between the eyes, and the other without a bar. The former helps protect the face, eye, and nose, although its vertical bar could obstruct the visual field. However, there are no reports of evaluations of how different FG configurations affect the visual function, which is important for sports performance.

Sports vision in which the relationship between sports and vision is a comprehensive study[4]. It has been suggested that visual functions have a great influence on the performance of a player, irrespective of the sport[5~7]. Evaluation parameter in sports vision include static visual acuity (SVA) and motion visual acuity (1. kinetic visual acuity (KVA), 2. dynamic visual acuity (DVA))[8, 9]. KVA is an evaluation method, in which measurements are made with the subjects watching a target (a Landolt ring) moving from the front toward them, and which reflects the central (brain) func-

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Figure 1 Face guards (FGs) in collision & contact sports

tion of recognizing a minute change in the form of an object[10~13]. DVA uses a target (a Landolt ring) moving horizontally in front of the eyes. It is suggested that it reflects saccadic and smooth eye movements[14].

In the present study, we estimated the sports vision with facial protection equipment. The purpose of this study was to evaluate the effects on SVA and KVA of various designs of FGs for contact & collision sports.

Methods

1. Subjects

All experimental procedures were conducted in accordance with World Medical Association's Declaration of Helsinki (Ethical Principles for Medical Research Involving Human Subjects). This study was also performed with approval from the ethics committee of St. Marianna University School of Medicine (approval number: 1976).

Ten collegiate American football players (all male; mean age: 21.1 years old) participated in this study. They all had corrected eyesight (some with contact lenses) of 0.7 or higher, which is generally required for sports[15].

2. Procedure

In this study, FGs for American football (NPX, Riddel, USA) were used with helmets (Air XP, Schutte, USA) just as in a playing situation. Three different measurement conditions were used: group A, no FGs (the naked eye); group B, FG without a vertical bar between the eyes, where the bar was resected from a FG; and group C, FG with a bar (**Figure 2**).

Measurements were done with a motion visual acuity tester (for SVA and KVA) (AS-4F, Kowa, Tokyo) (**Figure 3**) under the following conditions: a Landolt ring as a visual target; visual acuity value of 0.1 to 1.6; visual target luminance of 160 cd/m^2; and visual target distance of 3 to 50 m. During measurements, participants fixed the part of heads or helmets to the tester with same distances from eyes to the measuring windows of the tester. Measurement parameters were SVA and KVA; the correlation coefficient (r) between SVA and KVA was also calculated.

The participants were instructed to look through the measuring window of the AS-4F device and locate a Landolt ring, which resembles a "C." SVA was measured by having them identify the direction of the gap in the ring, with the SVA

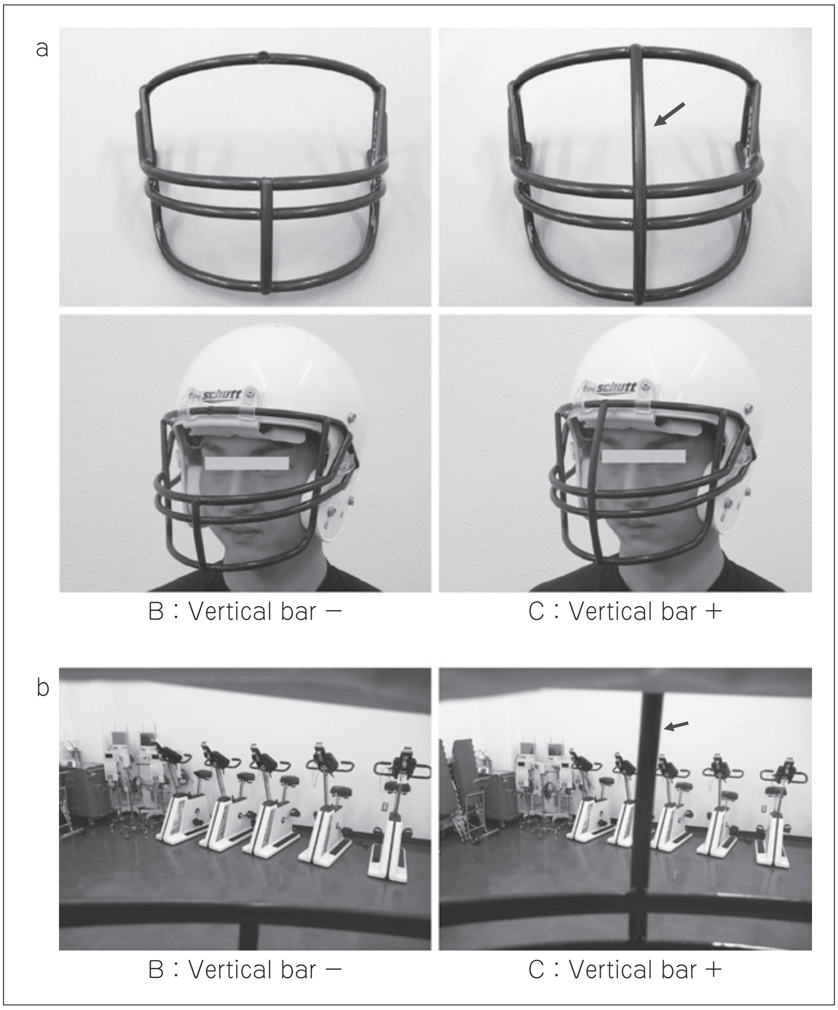

Figure 2　Tested face guards (FGs)
a. Classification of FGs
B: FG without a vertical bar between the eyes.
C: FG with a vertical bar between the eyes.
Arrow: vertical bar.
b. Field vision from inside of helmets
Abbreviations are the same as in Figure 2-a.
Arrow: vertical bar.

Figure 3　Motion visual acuity tester (AS-4F, Kowa, Tokyo)

score increasing as the ring decreases in size. KVA was measured as follows. The Landolt ring was set to appear to move towards the observer from a distance of 50m at a rate of 30km/hr. The participants were required to identify the correct direction of the gap as soon as possible by pressing a switch. The smaller the ring size was on identification, the higher the KVA level. Both SVA and KVA were converted and expressed as decimal visual acuity (visual acuity value)[16, 17]. We estimated values of SVA and KVA as LogMAR in this study[18, 19].

Table 1　SVA and KVA (LogMAR)

group	SVA LogMAR	KVA LogMAR
A: Naked eye	−0.083±0.118	0.311±0.254
B: Vertical bar−	−0.002±0.191	0.397±0.255
C: Vertical bar+	−0.037±0.200	0.387±0.278

There was no significant difference between groups A, B and C in SVA LogMAR and KVA LogMAR. Values are means±SDs. n=10 in each group.
A: no FGs (the naked eye).
Abbreviations are the same as in Figure 2-a.

Table 2　Correlation coefficient (Pearson) between SVA and KVA (LogMAR)

group	Correlation coefficient
A: Naked eye	0.517
B: Vertical bar−	0.588
C: Vertical bar+	0.321

Little correlation was found in group C (0.321).
n=10 in each group.
Abbreviations are the same as in Table 1.

KVA was measured 5 times for each participant (n=10). When participants made a mistake over three times to identify the correct direction of the gap, they tried all measurements again[19].

One of the 3 conditions (A, B or C) was randomly assigned to each participant with sufficient interval (15 minutes).

3. Statistical analysis

One-way analysis of variance and Pearson's correlation coefficient were used in the present study. Statistical significance was set at $p<0.05$.

Results

1. SVA (LogMAR)

SVA (LogMAR) is shown in **Table 1**. SVA was higher in the order of no FGs (group A: −0.083±0.118), FG with a bar (group C: −0.037±0.200), and FG without a bar (group B: −0.002±0.191), although there was no significant difference among these three groups.

2. KVA (LogMAR)

As shown in **Table 1**, similar to SVA, the KVA (LogMAR) was higher in the order of no FGs (group A: 0.311±0.254), FG with a bar (group C: 0.387±0.278), and FG without a bar (group B: 0.397±0.255), although there was also no significant difference among these three groups.

3. Correlation coefficient between SVA and KVA (LogMAR)

The correlation coefficients (r) between SVA and KVA (LogMAR) were 0.517, 0.588, and 0.321 in groups A, B, and C, respectively (**Table 2**). The coefficient for group C (FG with a bar) was a lower value than that for groups A and B.

Discussion

There have been many previous reports on sports and motion visual acuity[20～26]. Winograd evaluated 11 visual functions and batting ability in regular players, reserves, and ordinary students who did not play sports, and observed that regular players had better performance in binocular disparity, visual reaction time, and simple reaction time, but not in vision and batting[20].

There have also been studies on protective eyewear during sports and visual functions. Ing et al. evaluated the influence of polycarbonate hockey visors (half face shield) and sports goggles on visual functions in ice hockey, and reported that these kinds of protective eyewear did not have a negative influence on Snellen acuity, contrast sensitivity, the Ishihara color vision test, or foveal threshold, but they caused a moderate decrease in peripheral field threshold sensitivity, especially in the temporal crescent[2]. However, to date, there has been no report on the influence of variations in FG configurations on motion visual acuity closely related to actual performance.

In the present study, no significant difference was observed in effects on SVA and KVA by the presence of a vertical bar in FGs. This is useful information for players using FGs in contact & collision sports, because it is clear that a vertical bar does not inhibit the SVA and KVA.

On the other hand, the correlation in group C (with a vertical bar) was extremely low (r=0.321), although it has been assumed that there is originally a strong correlation between SVA and KVA[13]. It was strongly suggested that for some

Table 3　All data of SVA and KVA (LogMAR)

group A		SVA LogMAR	KVA LogMAR					
			Try 1	2	3	4	5	Avg.
player	1	−0.2041	0.3979	0.3979	0.6990	0.5229	0.3979	0.4831
	2	−0.0792	0.5229	0.5229	0.5229	0.5229	0.5229	0.5229
	3	−0.0792	0.1549	0.1549	0.2218	0.2218	0.0458	0.1599
	4	0.0000	1.0000	0.3010	0.6990	0.6990	0.5229	0.6444
	5	−0.1761	0.1549	0.0458	0.1549	0.0969	0.2218	0.1349
	6	0.1549	0.3979	0.3979	0.3979	0.3010	0.3979	0.3786
	7	−0.2041	0.0458	−0.0414	0.0000	0.0000	0.0000	0.0009
	8	−0.1761	0.0000	0.0458	0.0458	−0.0792	−0.0792	−0.0134
	9	0.0458	0.5229	1.0000	0.5229	0.5229	0.6990	0.6535
	10	−0.1139	−0.0414	0.0000	0.5229	0.0969	0.2218	0.1600

group B		SVA LogMAR	KVA LogMAR					
			Try 1	2	3	4	5	Avg.
player	1	−0.2041	0.5229	0.6990	0.3010	0.3010	0.3979	0.4444
	2	0.2218	0.5229	1.0000	0.3979	0.6990	0.5229	0.6285
	3	−0.2041	0.0458	0.0969	0.3979	0.0458	0.2218	0.1616
	4	−0.0414	1.0000	1.0000	0.3979	0.5229	0.5229	0.6887
	5	−0.1761	0.3979	0.1549	0.0969	0.1549	0.1549	0.1919
	6	0.2218	0.6990	0.3979	0.6990	0.6990	0.6990	0.6388
	7	−0.0414	0.2218	0.0000	0.0458	0.0000	0.1549	0.0845
	8	−0.1461	0.3979	0.0000	−0.0792	−0.0414	−0.0414	0.0472
	9	0.0458	0.6990	0.3979	0.3979	0.3010	0.3979	0.4388
	10	0.3010	0.5229	0.6990	1.0000	0.5229	0.5229	0.6535

group C		SVA LogMAR	KVA LogMAR					
			Try 1	2	3	4	5	Avg.
player	1	−0.2041	0.6990	0.3979	0.3979	0.5229	0.6990	0.5433
	2	−0.1761	0.3979	0.3979	0.5229	0.5229	0.5229	0.4729
	3	0.0000	0.0969	0.0969	0.0969	0.1549	0.0969	0.1085
	4	−0.1139	1.0000	0.5229	0.6990	0.5229	1.0000	0.7489
	5	−0.2041	0.2218	0.2218	0.0000	0.3979	0.1549	0.1993
	6	0.3979	1.0000	0.3979	0.6990	1.0000	1.0000	0.8194
	7	−0.1761	0.6990	0.3010	0.2218	0.1549	0.0969	0.2947
	8	−0.1461	0.1549	−0.0414	0.0969	−0.0414	0.0000	0.0338
	9	0.0969	0.0969	0.1549	0.1549	0.1549	0.0458	0.1215
	10	0.1549	0.5229	1.0000	0.1549	0.3010	0.6990	0.5356

Abbreviations are the same as in Table 1.
Data with underline: Individual trial data with SVA LogMAR ≧ KVA LogMAR.

athletes, using this type of FG leads to variations in SVA and KVA.

Table 3 shows all data of SVA and KVA (LogMAR) in the present study. It is said that KVA values are not higher than SVA values[13] (SVA LogMAR ＜ KVA LogMAR). However, some data (**Table 3**: data with under line in group C) appeared that KVA values were the same as SVA values or were higher than SVA values (SVA LogMAR ≧ KVA LogMAR). This implied that the presence of a vertical bar leaded to high KVA values. Since there were two objects in the visual field during the measurement, i.e., Landolt ring moving from the front and a vertical bar in the front, it was possible that some subjects exhibited higher KVA values by not recognizing the target with both eyes, but instead recognized the target with their dominant eye[27～29] and the bar with their other eye. However, this is speculative and the details are still unclear. Further evaluation is needed.

It was also conceivable that a vertical bar could have some effect on DVA, which is another type of motion visual acuity measured with a target moving horizontally, although this was not assessed in the present study. We anticipate that we will consider this in a future study.

From the present study, we concluded that, when a player chooses a FG, the player should consider the fact that a FG with a vertical bar does not directly affect SVA and KVA. However, some players could cause some variation between SVA and KVA. These results suggested that FG with a vertical bar is unstable for visual function during sports activity.

Conclusion

1. Effects of variations in configurations of FG for contact ＆ collision sports on SVA and KVA were evaluated.

2. There was no significant difference between SVA and KVA among group A (no FGs), group B (FG without a vertical bar), and group C (FG with a vertical bar).

3. There was little correlation between SVA and KVA in group C (FG with a bar), suggesting that there could be variation between SVA and KVA in some players.

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コンタクトスポーツにおけるフェースガードの形状が静止視力および動体視力に及ぼす影響

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キー･ワード：視力，フェースガード，アメリカンフットボール

〔要旨〕　スポーツ用フェースガード（FG）の形状の違い（顔面正中部の縦バーの有無）が，静止視力（SVA），および動体視力（KVA）に及ぼす影響について検討した．大学運動選手 10 人に対し，A：FG 無し，B：顔面正中部に縦バーが無い FG，C：顔面正中部に縦バーがある FG，の 3 条件下で動体視力計を用い SVA，および KVA を測定した．その結果，SVA，および KVA は 3 条件間で有意差はみられなかったが，SVA と KVA との相関係数は，A：0.517，B：0.588，C：0.321 と C が低く，本来 SVA と KVA には高い相関があるものの，顔面正中部に縦バーがある FG では，選手によって SVA と KVA にばらつきの出ることが示唆された．