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Article ► Dynamic Visual Acuity Training in Cricket Players

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ABSTRACT

Background: Dynamic visual acuity (DVA) is the ability of an observer to correctly identify details of a moving target and is considered to be important for tasks like driving. Dynamic Visual Acuity is better in athletes involved in sports such as basketball and baseball; however, no previous studies have considered the sport of cricket. We conducted a study to determine whether there was any difference in DVA between cricket and non-cricket players.

Method: Dynamic visual acuity was measured by asking subjects to identify the orientation of the gap of a moving Landolt C target as a four-alternative forced-choice task. The Landolt C targets had confusion bars surrounding them. The participants in the study were tested twice with a break of seven weeks. In between the two measurements, participants underwent two training sessions (similar to the testing sessions), each three weeks apart.

Results: The initial mean DVA for cricket players was 107.7 deg/sec, and the mean DVA for non-cricket players was 105.5 deg/sec, with a target size of 6/15. The subjects who participated in training (cricketers and non-cricketers) improved in DVA by 41 deg/sec in contrast to the improvement in the non-training subjects of 18 deg/sec ($p=0.0032$). The cricketers who participated in the training improved in DVA by 44 deg/sec, whereas the cricketers who did not participate in the training improved by 19 deg/sec ($p=0.0167$).

Conclusions: We found no significant difference in initial DVA between the cricket players and the non-cricket players. The training resulted in an extremely significant improvement in DVA performance by both the cricketers and non-cricketers.

Keywords: cricket, dynamic visual acuity, sports vision, vision training

Introduction

Sports vision is still a fairly new area of optometric research. Although there are many different visual attributes to consider, dynamic visual acuity (DVA) has been proven repeatedly to be important when considering sports vision.¹⁻⁸ Dynamic visual acuity is the ability of an observer to correctly identify details of a moving target. Factors that can influence DVA fall into two main categories: stimulus parameters and

human attributes. Factors like target luminance, angular velocity, and exposure time are examples of stimulus parameters that influence DVA. Human attributes that may influence DVA are the resolving power of the eye, oculomotor abilities, and the ability of the subject to be able to interpret what is presented to them. The eye can follow targets accurately at speeds of up to 30 deg/sec; after this the pursuit of targets involves saccadic movements to keep the target

on the fovea.^{1,9} This is the main reason why DVA reduces as the angular velocity increases. If the subject is able to move their head, this reduces the need for saccadic movements, and DVA improves in comparison to fixed head measurements.¹

In many parts of the world, cricket is a major summer sport with a very strong following. It involves people of all ages, and it is considered quite an honour to represent your school, province, or country. As with baseball, basketball, and many other sports which require hand-eye coordination, the visual demands of cricket need to be considered so that relevant visual testing can be conducted.



A video explaining the basics of cricket.

The most visually demanding cricketing skill is batting. A batsman needs to be able to identify qualities of a cricket ball coming at them at speeds of up to 150 km/h. The direction and positioning of the seam coupled with where the ball comes out of the bowler's hand can directly influence the path of the delivery. Anticipation of where the ball will land and what direction it will bounce influences the shot selection for batsmen.¹⁰ Coaches often advise their batsmen of the importance of watching the bowler just before and during his run-up to pick up any postural cues to identify the position of the seam and shiny or rough side of the ball in order to be able to predict what delivery is about to be bowled.¹¹ Graham Gooch, former England cricket captain and batting coach, suggests that batters

concentrate on looking at the bowler as he runs in, look at his arm, then look at the ball.¹⁰



A video demonstrating batting techniques in cricket.

As there is relative movement between the observer (batsman) and the object of interest (cricket ball), DVA has been reported in the literature as being the most important aspect to consider in sports vision.² It has been said that a good batsman must have "fast eyes."¹⁰

Another important attribute of playing cricket is the ability to be able to catch a ball when it is travelling towards you. Sanderson and Whiting³ have studied catching ability and visual attributes such as static and DVA. Their conclusion was the better the DVA, the better a person was at catching a tennis ball.

The most common method of measuring DVA is to present a moving target (such as a Landolt C) across a screen. The participant must then identify the orientation of the gap in the C.^{1,5,7,12} Another method used is to project a tennis ball at a person in darkness. The ball is then lit up for approximately 800msec and then plunged back into darkness. From this short view, the path of the tennis ball should be predicted, and thus the ball should be caught.³ The theory behind this type of method is that accurate perception of moving objects requires efficient oculomotor adjustments that only occupy a short time. When exposure time is limited, these compensatory eye movements are critical, and hypothetically, exceptional athletes involved in fast ball sports possess this control to process the information under dynamic conditions.

There is conflicting evidence in the literature when it comes to assessing whether DVA is better in athletes than non-athletes. Many experiments have shown that DVA is in fact significantly better in athletes than non-athletes.^{1,4,5} Beals et al.⁵ found a significant correlation between shooting performance and DVA in basketball players; however, his use of certain statistics has been queried.⁶ The one factor that can strongly be concluded from his study regardless of statistical analysis is the importance of DVA in relation to basketball shooting. Ishigaki and Miyao¹² found no difference in DVA between athletes (fast ball sports such as baseball, tennis, and badminton) and non-athletes when large Landolt C targets were used; however, when smaller targets were used, the athletes had significantly better DVA. Morris and Kreighbaum⁷ compared DVA of high and low percentage basketball shooters. They found no significant difference between those player groups. However, comparison of the variability of DVA between high and low percentage shooters showed less variability in the higher percentage shooters. The main reason their research tends to contradict the previously mentioned work^{1,4,5,12} about differences in DVA is due to their lack of a non-athlete control group.

Long and Riggs¹³ were the first to compare DVA with free head rather than fixed head viewing. They however found no difference between the athletes and the non-athletes. Free head viewing is more representative of real world situations, so optometrists who favour a more behavioural approach may consider this a more appropriate experimental design.

Much of the literature concerning visual training has shown positive effects on visual attributes.^{8,13-15} Fergenson and Suzansky¹⁶ showed that repeated measures as a way of training significantly improved DVA in eight of their sixteen different testing conditions. Training effects were more remarkable in those who had the worst DVA prior to training.¹⁴

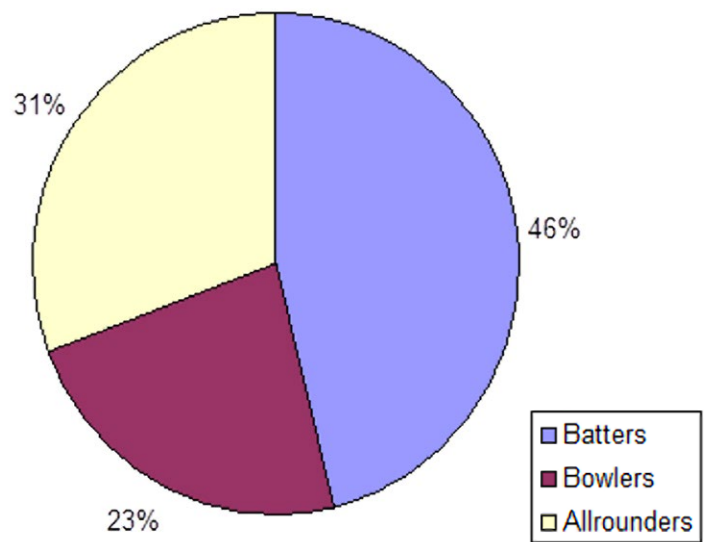


Figure 1: Distribution of cricket player specialities

There are commercially available training programmes that claim to be able to improve visual attributes which correspond to better sporting performance. Two studies have been done to test the claims of these programmes. Long¹⁷ found no significant difference in DVA between those who participated in the training programme (Eyerobics) and those who did not. Wood and Abernathy¹⁸ tested other training programmes and found a significant improvement in DVA by those who had trained their skills. The difference in outcomes of the above studies could be due to experiment design, with Long¹⁷ only having 4 pre-set speeds to measure DVA rather than an incremental speed variance to measure DVA more accurately. Despite measuring an improvement in DVA with training, Wood and Abernathy¹⁸ could not conclude that this improvement resulted in improved sporting performance. It is difficult to assess improved sporting performance due to the number of variables involved.

Methods and Procedure

Subjects

Subjects were divided into two groups: those who play cricket competitively and those who do not participate in the sport at all (or any other similar sports that require

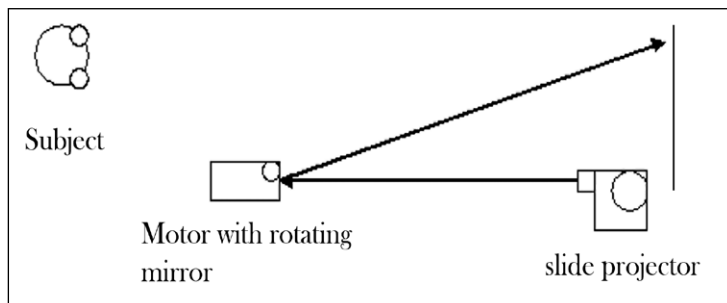


Figure 2: Demonstration of equipment set-up

good eye hand co-ordination such as tennis, squash, and hockey). The cricketers were recruited, with the help of Auckland Cricket, partly from the Auckland under-19 winter development training squad (5) and other people known to the testers who played cricket (8). There were 6 specialist batsmen, 4 allrounders, and 3 bowlers participating in this study (Figure 1).

The other group (non-cricketers/control) were drawn mainly from the University of Auckland Department of Optometry and Vision Science, both students and tutors. There were 18 subjects in this group. All subjects in both groups were male, as there is a proven difference found in DVA between males and females.¹⁹ As age can affect DVA,¹⁹ a minimum age of 17 was put in place. This is two years above the age (15) at which mature DVA levels are reached.

All subjects were fully informed of the procedures after reading the Participant Information Sheet and were encouraged to ask questions. Once they were confident that they understood what was required, they signed consent forms and then answered a questionnaire relating to their ability at cricket and any existing visual correction. The University of Auckland Human Subjects Ethics Committee approved the research - ref: 2002/043.

Methods

The methods used were based on the research and procedures of Rouse et al.¹ Targets were projected onto the wall from a slide projector via a motorised rotating mirror (Figure 2). The distance between the projector and the

Table 1: Results of each subject for initial DVA comparisons

Non-Cricket Players		Cricket Players	
Subject #	DVA (deg/sec)	Subject #	DVA (deg/sec)
1	90	1	110
2	110	2	120
3	80	3	100
4	120	4	130
5	130	5	110
6	140	6	100
7	120	7	130
8	60	8	110
9	80	9	100
10	100	10	90
11	110	11	100
12	100	12	90
13	100	13	110
14	130		
15	140		
16	120		
17	100		
18	70		
Mean	105.5	Mean	107.7
SD	23.32	SD	13.01
SEM	5.496	SEM	3.608

motorised mirror was 2 m. The apparatus also included a shutter that enabled the target to be seen for only 600 msec so that the subjects couldn't track the target around the room. The rotating mirror was able to rotate both clockwise and anti-clockwise so that the rotation direction could be randomised. This was done in order to counter lab artificiality and to make the measurements more real.

The targets used to project onto the wall were Landolt C targets surrounded by confusion bars. The size of the gap on the wall was 2.5 mm, and the subject viewed this from 3 m. This target was equivalent to a 6/15 letter. We kept the target size the same throughout the experiment and varied the speed in order to determine DVA.

The orientation of the targets was randomly assigned, and subjects were asked to identify in which direction the gap in the C appeared. This was a four-alternative forced-choice method. The threshold for measuring DVA was set at 4 out of 5 (80%) correctly identified targets.

All testing was conducted in the same room at the medical school with consistent lighting conditions. The room luminance at

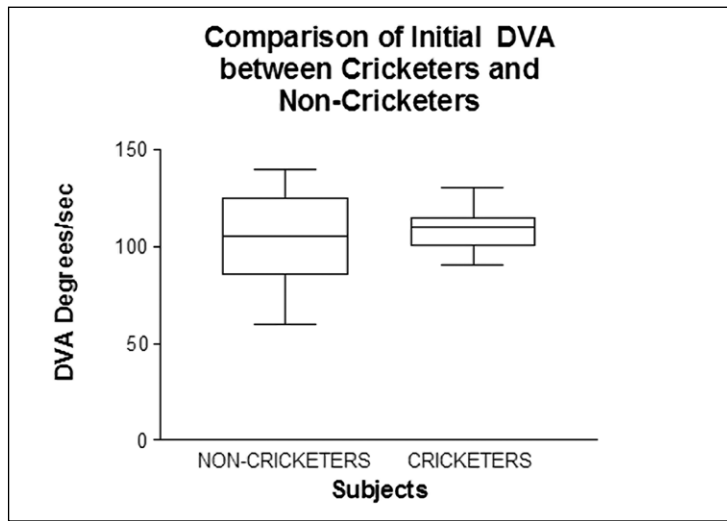


Figure 3: Comparison of Initial DVA between Cricketers and Non-cricketers

the participant was 80 cd/m² and at the screen was 40 cd/m². The subject viewed the targets starting at the highest speed. This speed was decreased until the subject's threshold was reached.

If the subject was interested in participating in the training aspect of this study, they were asked back for two training sessions. These two sessions were identical to the initial measurement and were scheduled three weeks apart. These sessions would generally take 20 minutes. Once the training was completed, all the subjects were asked back for a second measurement of DVA to ascertain if there had been any improvement in DVA for those who had been in training in comparison to those who did not participate in the training.

Results

The initial DVA for the individual subjects is shown in Table 1. The mean DVA of the cricket players is 107.7 deg/sec with a standard deviation (SD) of 13.01 and a standard error of measurement (SEM) of 3.608. The SEM indicates the accuracy of the measurements, whereas the SD measures the spread of the results. The mean DVA of the non-cricket players was 105.5 deg/sec with a SD of 23.32 and a SEM of 5.496. Comparison of the mean DVA of these two groups with an unpaired t-test shows no significant difference ($p > 0.05$)

Table 2: Results of Initial DVA for different

Cricketing Specialities	Batters	Bowlers	Allrounders
	110	100	130
	120	110	100
	130	110	90
	110		100
	100		
	90		
	110		
Mean	110	106.6667	105

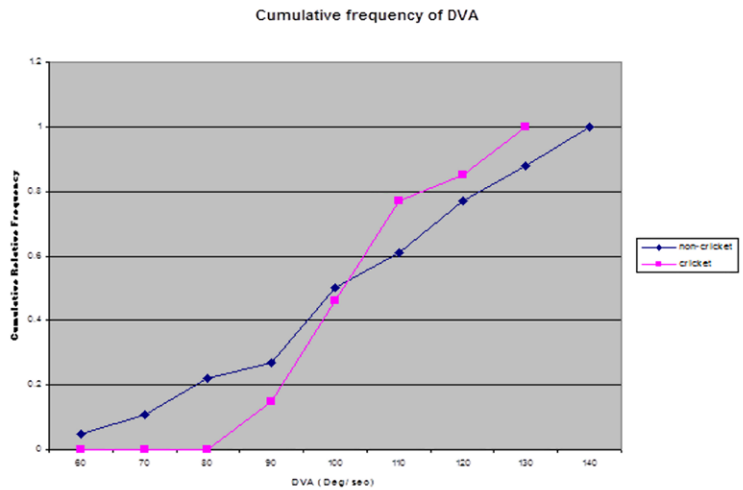


Figure 4: Cumulative frequency of initial DVA results

(Figure 3). The shorter inter-quartile ranges for the cricket players demonstrates less variability in measurements, backed up by the lower SD and SEM. The whole range of results for the cricketers almost falls within the upper to lower quartile range for the non-cricketers.

Figure 4 is a cumulative frequency histogram and indicates the greater spread of results of the non-cricketers. The cricket players' results are all within a 40 deg/sec range, in comparison to the non-cricketers, whose results fall within an 80 deg/sec range. This small spread of results is further evident in Figure 5. At an angular velocity of 110 deg/sec, 78% of the cricketers have a lower DVA in comparison to the non-cricketers, where 60% have a lower DVA. Now looking at 90 deg/sec, the roles are reversed. At this angular velocity, 18% of the cricketers have a lower DVA, but 28% of the non-cricketers have a lower DVA.

We also investigated the difference in initial DVA between batsmen and bowlers. Table 2

Table 3: Training results for each subject

Training			Non-Training		
Subject #	Initial DVA (deg/sec)	Final DVA (deg/sec)	Subject #	Initial DVA (deg/sec)	Final DVA (deg/sec)
1	100	150	1	100	140
2	100	150	2	100	140
3	90	150	3	110	120
4	120	150	4	70	120
5	110	150	5	100	100
6	120	150	6	80	110
7	110	130	7	60	100
8	100	150	8	120	110
9	90	140	9	140	150
10	110	140	10	130	140
			11	90	120
			12	80	100
			13	120	140
			14	130	150
			15	140	130
			16	100	70
			17	130	150
			18	110	140
			19	110	120
			20	100	130
Mean	105	146	Mean	106	124
SD	10.8	6.992	SD	22.57	21.13
SEM	3.416	2.21	SEM	5.05	4.72

shows the results for the individual specialities. The mean DVA for batsmen was 110 deg/sec. The batsmen represented almost half of the cricketer group. The mean for the cricket players as a group was lower than this mean for batsmen. The mean DVA for the bowlers was 106.7 deg/sec, and the mean for the allrounders was 105 deg/sec. It is hard to compare these groups as the sample size is very small. The batsmen have the same spread of results as the cricketers, 90 to 130 deg/sec. The bowlers have very similar results to each other, with a range of 100 to 110 deg/sec.

Table 3 shows the results of the training. Ten subjects were able to participate in the training. Twenty subjects were unable to participate but were able to return for a second baseline measurement. One subject from the initial measurement was unable to return for the second measurement and thus is not included in the training results analysis.

Within the training group, there were eight cricket players and two non-cricket players;

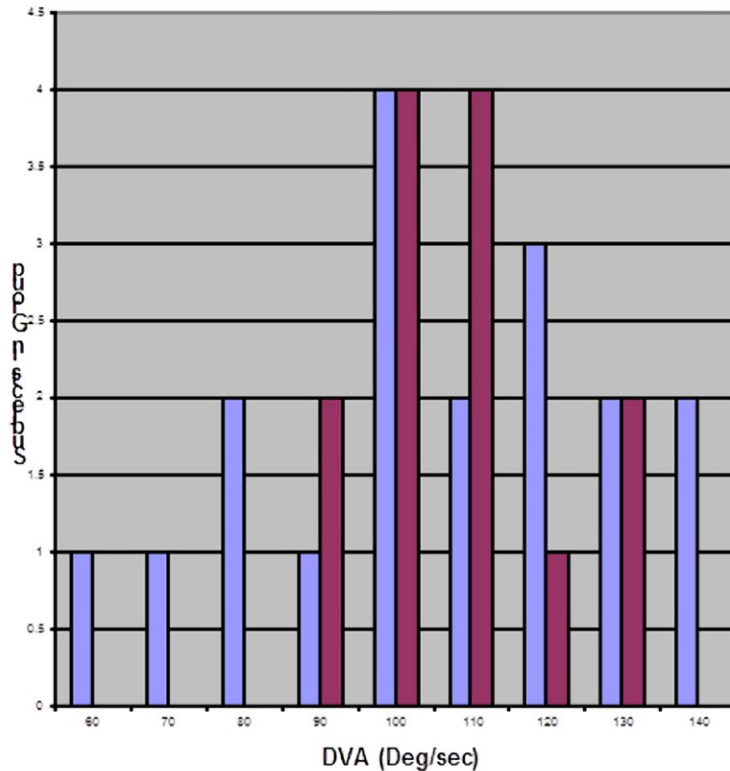


Figure 5: Comparison of DVA in cricketers and non-cricketers

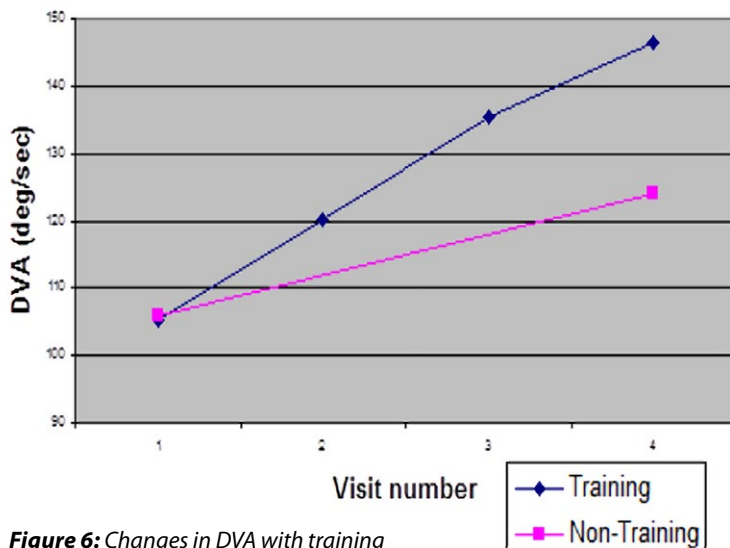


Figure 6: Changes in DVA with training

likewise in the non-training group, there were 16 non-cricket players and four cricket players. The mean DVA for the training group after participating in the training was 146 deg/sec with a SD of 6.99 deg/sec and SEM of 2.211. Those subjects who could not participate in the training still improved at the second measurement (mean DVA of 124 deg/sec). Figure 6 displays the improvement seen in both the training and non-training groups. This graph shows an obvious increase in the DVA of those who participated in the training

Table 4: p-Values to compare training

Improvements Between Sessions	p-Value
Second Session	0.1127 not significant
Third Session	0.0002 statistically significant
Final Session	<0.001 statistically significant

Table 5: Table of results for training and

Non-Training of Cricket Players		Non-Training	
DVA Initial visit (deg/sec)	DVA Final visit (deg/sec)	DVA Initial visit (deg/sec)	DVA Final visit (deg/sec)
100	150	130	150
100	150	110	140
90	150	130	
120	150	100	130
110	150	110	120
90	140		
110	130		
100	150		
Mean 102.5	146.25	116	135

and also the improvement seen by those who did not participate in training. A learning curve could explain the improvement by those not undergoing training.

Statistical analysis of the the improvement with training was performed to show the significance in improvement at each visit. T-tests comparing each individual training session to initial DVA were performed and showed the p-values listed in Table 4. The data within this group is matched as it is the same subjects at each visit. Due to this, the analysis of this data is more powerful and significant of a true training effect. Interestingly, there is no significant improvement in the DVA measured between the first and second visits, but the improvement starts by the third visit in relation to the first visit. T-test analysis of these results shows an extremely significant improvement in DVA between the first and final visit of the training cricket players ($p < 0.001$).

We also looked at the DVA at each individual session in comparison to the one before it. Each session showed an improvement in DVA, but there was no significant difference in this improvement until comparing the fourth and final sessions to the third ($p = 0.0499$). Graphical

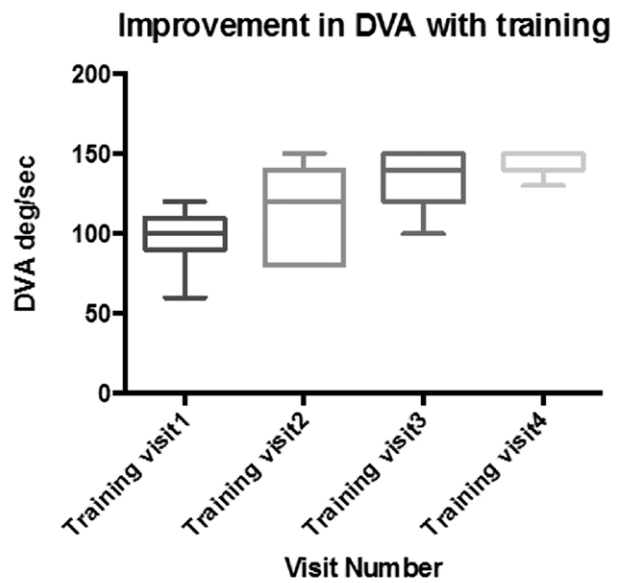


Figure 7: Changes in DVA at each training session

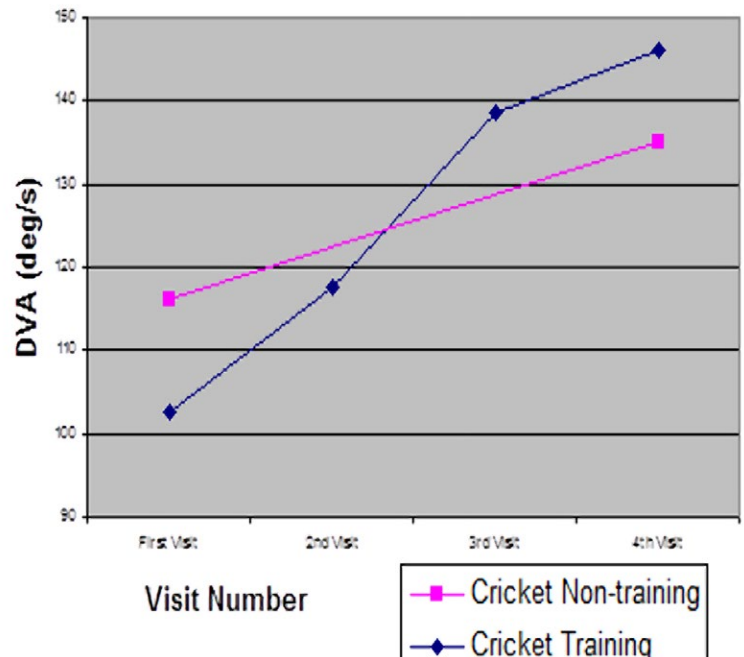


Figure 8: Comparison of DVA in cricketers with and without training

analysis of these individual sessions is shown in Figure 7.

Analysis of the training of cricket players only was also performed. Table 5 demonstrates the values for this group. There is one cricketer who could not return for the final comparison measurement of DVA. The results show a higher DVA in the initial measurement of the non-training subjects; however, this difference is not significant. These results and the significant improvement in the training cricket players are further backed up in Figure 8.

The difference in DVA between the training and non-training players was statistically significant ($p=0.0167$), although the sample size of the cricketers involved in both groups is small and would have to be much larger to make real comparisons in the difference in mean DVA after the training. The mean DVA of the overall training group (with cricketers and non-cricketers in each group) was also compared with the mean DVA of the non-training group. The difference between the two means is 22 deg/sec but is deemed not to be a statistically significant difference ($p>0.05$). To find a statistically significant difference with our sample size, the difference in DVA would have had to be at least 29 deg/sec, or we would have needed larger sample sizes, approximately 30 in each group (ascertained using Stat Mate programme). It is difficult to make comparisons between the overall training and non-training groups as they are poorly matched with both cricket players and non-cricket players in each group.

Discussion

In this study, the cricket players had a mean DVA 2.2 deg/sec higher than the control group. While we cannot make broad claims due to the limitation in sample size, in this study, a statistically significant difference in DVA between those people who played cricket and those who did not was not found. Our results are not the same as previously published work in the area of DVA.^{1,4,5,12}

It is fairly hard to make any major conclusions from this work, as the sample size was very small; thus, it is more difficult to ascertain statistically significant differences. One possible explanation for the lack of significance in comparison to other studies is that previous research has always used college athletes or those who have exceptional abilities. Less than half our cricketer group was from the Auckland Under-19 Development Squad, and the rest were friends of the researchers. Although the cricket players from

the Auckland squad are undoubtedly the calibre of college athletes, the remainder of the group may not have been.

We found a significant statistical difference in the DVA of those participants in the training group between their first measurement and their last measurement using t-test statistical analysis. A limiting factor in our training study was the inability of the motor to rotate the target faster than 150 deg/sec. We believe that we could have found an even greater improvement in DVA with training had we been able to get the target to move faster. If this faster speed had been available, we may have found a statistically significant difference between the mean DVA of the training group and the non-training group at the final measurement. The difference we found was 22 deg/sec, and we needed to find a difference of 29 deg/sec with our sample size to find a statistically significant difference.

The experiment set-up we used was similar to that used by Rouse et al.¹ In that particular study, the target used was 6/9 Snellen equivalent acuity. Our target was larger (6/15) but had confusion bars surrounding the C. As confusion bars were added, the target was made bigger, as the task was effectively harder. In comparison to Rouse et al., the task might have been made too easy.¹ When the target was bigger, the difference between the athletes and non-athletes was not significant.⁷ If a smaller target was used, it is possible that a statistically significant difference in the initial comparison of DVA between the cricket players and the control group would have been found.

As we have used a descending limit, our results could possibly be lower than normal; however, it is a constant bias among the results, and therefore comparisons between our data can still be made. Another potential constant bias is the screen design onto which the target was projected. This screen was flat and not curved. This resulted in target blur at the beginning and end of the presentation. The target was only focussed for 2 m, thus we

needed a screen that was curved with a radius of 2 m. This blur was constant for everybody; however, an individual's tolerance of blur is not constant, so this adds another potential error in measurement.

Training of DVA produced a significant improvement by those who participated in the training. This confirms findings previously documented in the literature that suggest that training has a positive impact on visual skills.^{8,13-16} The improvement in DVA was not merely due to familiarity with the test. When analysed, there was not a significant difference in DVA between the first and second visits ($p=0.1127$), but the improvement started from the third visit and improved further by the fourth and final visit ($p<0.001$). This is further backed up by the fact that those subjects who could not participate in training but who returned for a second measurement to make comparisons had an improvement in DVA, indicative of familiarity, but this improvement was not significant.

Future studies should look to investigate the transfer of these improved DVA skills to on-field game skills and performance. An extension to this research would be to measure the ability of cricket players to identify seam location and orientation of a cricket ball delivered at different speeds pre- and post-training of DVA. The expected improvement in seam identification should directly translate to improved on-field performance, as this is a specific skill required for batting performance. It is not just batting, though, that requires good DVA. The improved skills should also improve the abilities of catching and throwing to targets whilst moving.

Conclusions

We found there to be no significant difference in DVA between cricket players and non-cricket players at the initial visit. Small sample sizes and a lack of high-performing cricket players in our study may have contributed to this. What we did find from this study was that there is certainly an improvement in DVA with training that is above

the expected learning curve and familiarity with repeated measures testing. This is the more significant finding from this study. Both groups had an improvement in DVA on repeated measures, indicating a familiarity improvement. At the third and fourth measurements, the training group made the most gains in their improved DVA. Future directions for this study would be to look at translating this improved DVA to improved on-field performance. If these future studies could prove increased on-field performance following DVA training, this DVA training should become a standard addition to a cricket player's training programme.

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