VI Judo Classification Research Report

Research and Development Centre for Athletes with Vision Impairment

Vrije Universiteit Amsterdam

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22nd May 2020

1 Introduction

The Research and Development Centre for the Classification of Athletes with Vision Impairment in Amsterdam conducted the *VI Judo Classification Research Project* to provide recommendations for a new evidence-based classification system for VI judo. In this report, we provide a summary of research results and recommendations.

Executive summary of recommendations from the VI Judo Classification Research Project:

1. Set a more severe minimum impairment criterion for visual acuity at 1.3 logMAR, as opposed to the 1.0 logMAR for inclusion in the existing system.
2. Set a less severe minimum impairment criterion for the visual field at 30 degrees radius, as opposed to the 20 degrees radius for inclusion in the existing system.
3. Split VI judo into two sport classes rather than the one class used in the existing system: one class for athletes with visual acuity between 1.3 and 2.5 logMAR (inclusive), and another class for athletes with more severe impairment with visual acuity worse than 2.5 logMAR.
4. Vision testing during classification should be conducted while testing both eyes together rather than relying on the results of the best eye alone.

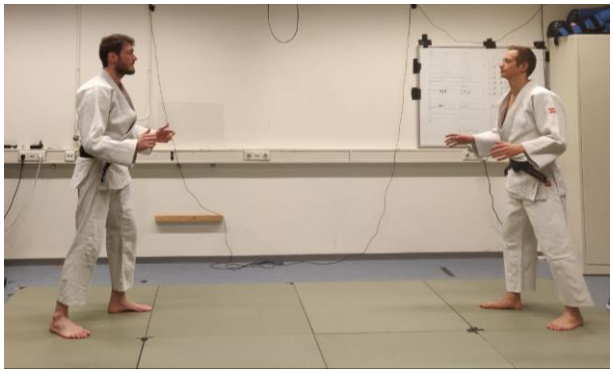
Below we provide an overview of the research studies that led to these recommendations. Section 2 provides an overview of all the studies conducted within the project while Sections 3, 4 and 5 explain each of these studies and their results in more detail. We conclude in Section 6 with an explanation of our main recommendations as well as additional suggestions.

2 Overview of the research project

The *VI Judo Classification Research Project* comprised the following research studies:

1. **Expert consultation**
   A panel of current and former VI judo athletes, coaches, and administrators completed a series of surveys to provide guidance for classification research in VI judo.
2. **Impairment-performance relationship**
   Across five different research studies, we gathered data to understand the relationship between vision impairment and judo performance. These studies aimed to establish evidence-based **minimum impairment criteria** as well as **sport class criteria**.

   i. **<u>Minimum impairment criteria (two studies)</u>**
   These studies aimed to establish the least severe level of vision impairment that would decrease performance in able-sighted judo, i.e. when both judokas start the fight without a grip in place. The results of these studies led to recommendations for new evidence-based minimum impairment criteria for VI judo.



   ii. **<u>Sport class criteria (three studies)</u>**
   These studies aimed to establish how vision impairment impacts performance in the Paralympic form of judo, i.e. when both judokas start the fight with their grip in place. The results of this study led to recommendations for new evidence-based sport class criteria for VI judo.

3 Expert consultation

3.1 Aim and method

The aim of this study was to establish expert opinion on the requirements for an evidence-based system of classification for VI judo. IBSA assisted us to identify a panel of eighteen experts in VI judo who participated in three rounds of web-based surveys (Figure 1). Between rounds, results were summarised and further questions were asked on topics where there was disagreement amongst the panel.

Figure 1: *Background of the VI judo experts who participated in three rounds of online surveys. The panel consisted of athletes (35%), coaches (30%), administrators (13%), referees (13%) and classifiers (9%).*

3.2 Main results

The panel reached consensus that the current classification system in judo does not (entirely) fulfil the aim of classification as outlined in the IPC Athlete Classification Code, which is *to minimise the impact of eligible impairments on the outcome of competition*. The panel expressed an opinion that:

(i) Blind and partially sighted judokas should not compete against each other in the same class;

(ii) Additional measures of visual function might be needed to accurately evaluate a judoka's impairment experienced during competition;

(iii) The minimum impairment criteria (MIC) should represent a more severe level of impairment to ensure that all those included possess a level of VI that indeed decreases performance in judo;

(iv) Classification should be based on the results when testing both eyes together rather than the current practice of classification using the test results of the best eye only.

(v) Legitimate competition could be undermined by some judokas intentionally underperforming on classification tests.

It is important to state that these findings provide guidance for our empirical research to establish minimum impairment criteria and sport class criteria for VI judo. The findings themselves do not necessarily count as 'evidence' for an evidence-based system of classification.

The full explanation of the results can be found here:

Krabben, K. J., Ravensbergen, R. H. J. C., Nakamoto, H., & Mann, D. L. (2019). The development of evidence-based classification of vision impairment in Judo: A Delphi study. Frontiers in Psychology, 10, 1-12. https://doi.org/10.3389/fpsyg.2019.00098

4 Minimum impairment criteria

Under the existing system, athletes are eligible to compete in VI judo when their visual acuity[1] is equal to or worse than 1.0 logMAR units, or when their visual field[2] is less than 20 degrees radius. These minimum impairment criteria are not evidence-based nor sport-specific.

The Joint IPC & IBSA Position Stand on Classification for Athletes with Vision Impairment states that the minimum impairment criteria should be established using the able-sighted equivalent of the sport. In the case of judo, this means that the minimum impairment criteria should be set when examining performance *without* the grip in place at the start of the fight. This helps to establish the level of impairment that would limit an athlete's performance when competing against those without impairment and therefore should qualify them to compete in para-sports.

We conducted two studies to inform the development of an evidence-based minimum impairment criteria for VI judo. In both studies, the participants were able-sighted experienced judokas who took part in a series of grip fighting exchanges under able-sighted judo rules. We focused on the impact of impairment on grip fighting, which is not only "one of the most important and fundamental judo skills" (Jimmy Pedro, Olympic medallist), but also presumably the most visually demanding aspect of able-sighted judo. It is therefore the first aspect of judo performance that is expected to be impacted in the presence of vision impairment.

4.1 Minimum impairment criteria for visual acuity

4.1.1 Aim and method

The aim of this study was to determine the amount of impairment to visual acuity that would decrease performance in able-sighted judo. We temporarily blurred the vision of participants using a series of different blurring foils attached to swimming goggles. Twenty-eight able-sighted, advanced (brown or black belt) judokas participated in pairs (i.e., fourteen pairs). Pairs took part in seventy grip fighting exchanges in total under four different blur comparisons (Figure 2). In each condition, we tested the visual acuity of the judokas. Visual acuity was tested with both eyes together, as recommended by our expert panel (Section 3.2). Performance in each trial was independently self-rated by both participants to determine who dominated the gripping exchange. A validation check showed that the performance ratings of the participants correlated with those of an expert observer (a member of the research team who holds expertise in judo as a third degree black belt and a national level judo coach).

[1] Visual acuity is a measure of the sharpness of vision. Visual acuity is measured in logMAR units, with higher values representing worse visual acuity.

[2] Visual field is a measure of the area of peripheral vision with which an individual can see (i.e., without moving their eyes). Visual field is measured in degrees radius, with higher values representing a larger visual field.

4.1.2 Main results

Each athlete in the study experienced four different levels of blur, including a 'baseline' condition with minimal blur (a pilot test showed that this minimal blur did not decrease performance compared to grip fighting with normal vision). Figure 2 below shows the grip fighting performance for each of the four blur levels. There was no decrease in performance when participants experienced 1.0 logMAR blur if compared to each participant's baseline performance when blur was not expected to impact performance. This suggests that the current minimum impairment criteria of 1.0 logMAR does not impact grip fighting and therefore might not be a severe enough level of impairment for inclusion in VI judo. There were significant decreases in performance for the remaining two levels of blur (1.3 logMAR and 2.1 logMAR), providing the first suggestion that the minimum impairment critera should be set close to 1.3 logMAR (see Figure 2).

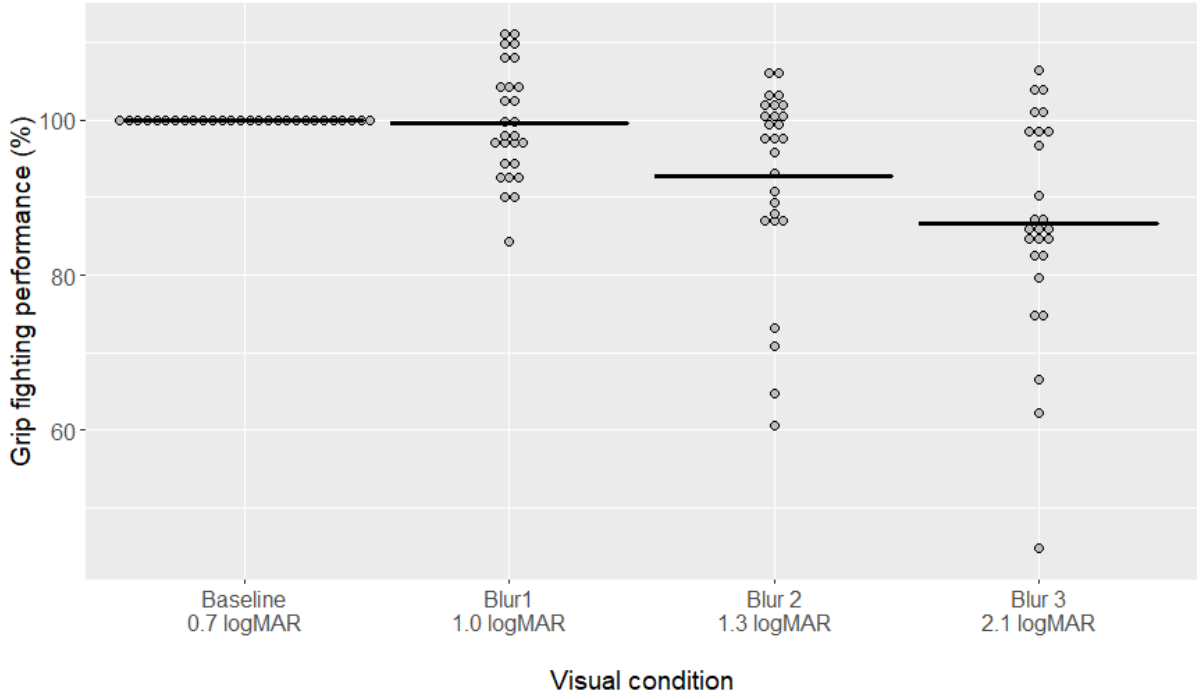


***Figure 2**: Grip fighting performance in different visual conditions. The logMAR scores on the x-axis show the average visual acuity impairment simulated by the respective level of blur (higher logMAR scores represent worse visual acuity). Each dot represents the average score of one participant in each of the different visual conditions. Scores obtained in the baseline condition are set to 100 for each participant. Scores in the three experimental conditions (blur 1 to 3) are expressed relative to this baseline. Black lines represent the average score in each visual condition.*

Ideally, a minimum impairment criteria should ensure that all athletes qualify to compete if their impairment genuinely impacts their performance, and conversely should ensure that no athletes qualify to compete if they do not have an impairment that impacts performance. However, our results show that this is not always possible. Figure 2 shows that for the same level of blur, performance is below what would be expected for some athletes (i.e., considering normal variation in performance across different trials), but not for others. To identify the optimal minimum impairment criteria, we therefore examined how different visual acuity cut-offs would impact the sensitivity and the specificity of classification. An MIC with optimal *sensitivity* is one that correctly includes all judokas who should be included (i.e., those who are performing below expected). A minimum impairment criteria with optimal *specificity* will correctly exclude all judokas who should not be included (i.e., those who are still performing as expected). Generally, setting the MIC at a

more severe degree of impairment will increase the specificity of classification (accurately excluding those who should not be in) but at the cost of reduced sensitivity (falsely excluding those who *should* be in), and vice versa. Youden's J is a measure used to find the optimal balance between sensitivity and specificity. We found that Youden's J is optimal at a minimum impairment criteria between 1.3 and 1.5 logMAR (Figure 3). This means that the number of correctly classified individuals is maximised with a minimum impairment criteria within this range.

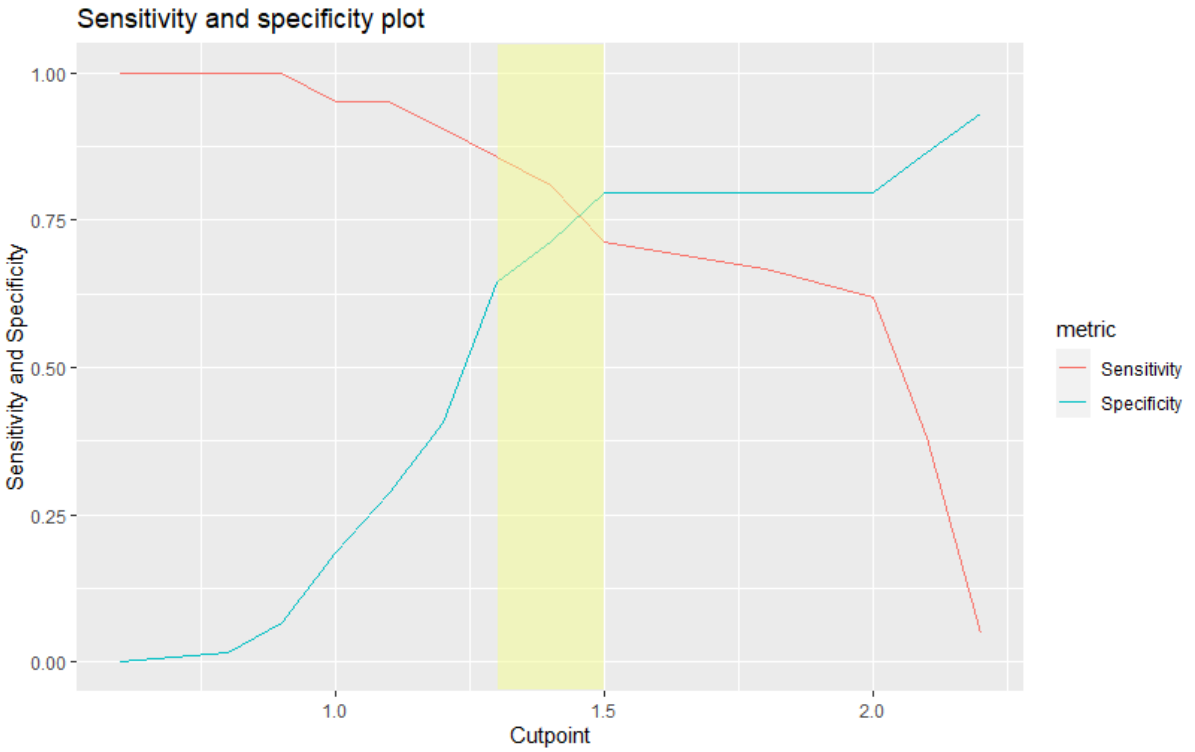


***Figure 3**: Sensitivity (correctly including judokas who should qualify to compete; red line) and specificity (correctly excluding judokas who should not qualify to compete; blue line) for different visual acuity cut-off points. Sensitivity and specificity are rated from 0 to 1, where higher values represent better scores. The yellow shaded area between 1.3 and 1.5 logMAR shows the visual acuity range where the balance between sensitivity and specificity (Youden's J) is optimal.*

The results show that the minimum impairment criteria should be set to *at least* 1.3 logMAR units. Both Youden's J as well as other additional statistical analyses using machine learning suggested a cut-off of 1.4 logMAR might be appropriate. In addition, the design of this study also, if anything, underestimates how severe the minimum impairment criteria should be. Participants in our study were not normally vision impaired and had only limited time to adapt to the simulated impairment before they were required to fight. If we would have given them more time to adapt, or if they were to be actual para athletes with a genuine vision impairment, we might have, if anything, expected participants to adapt to the impairment and show no decrease in performance at 1.3 logMAR. A recommended minimum impairment criteria of 1.3 logMAR is therefore a conservative choice, minimising the risk of falsely excluding judokas who do have an impairment to their performance.

A manuscript containing the full explanation of the results of this study is in preparation to be submitted to a scientific journal.

Recommendation

The results of this study suggest that the current MIC for visual acuity is not severe enough. We recommend a new MIC of 1.3 logMAR, increasing the likelihood that eligible athletes have an impairment that genuinely impacts their ability to compete in able-sighted judo against fully sighted opponents.

4.2 Minimum impairment criteria for the visual field

4.2.1 Aim and method

Studies of gaze behaviour in different combat sports (e.g., judo, boxing, karate) suggest that experts in these sports mostly direct their eyes toward the head or chest of their opponent. Using the head or chest as a "visual anchor", the athlete is then able to use their peripheral (side) vision to monitor the position of the opponent's limbs, helping them to anticipate incoming attacks under the high spatiotemporal constraints of combat sports. Yet it wasn't clear how much peripheral vision is needed to monitor those limbs effectively. The aim of this study was therefore to determine the amount of impairment to the visual field that would decrease performance in able-sighted judo.

Because visual field impairments are difficult to simulate, we used a different approach to determine the size of the visual field that might be needed for optimal performance in judo. In this study, seven able-sighted, advanced (brown or black belt) judokas wore eye tracking glasses that showed where they were looking whilst performing grip fighting tasks (see Figure 4). We also tracked the 3D position of each athlete's head along with their opponent's head and hands to determine the area of visual field that might be required for judo grip fighting.

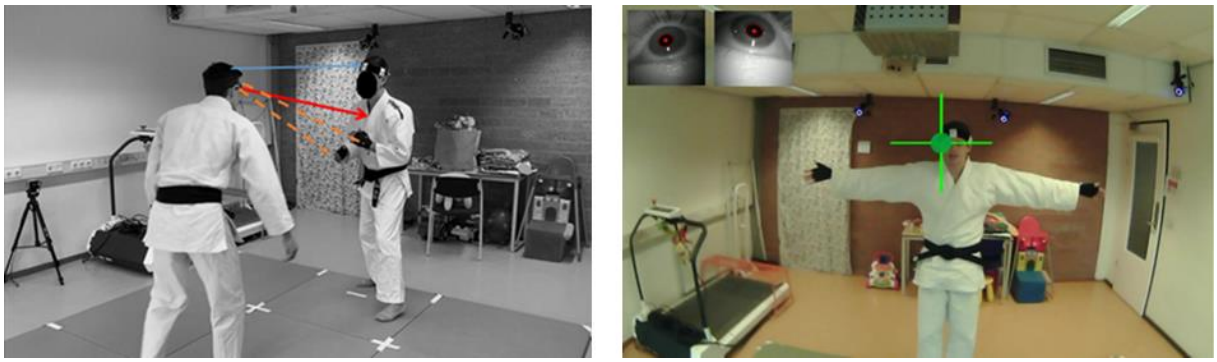


***Figure 4**: Gaze analysis of judokas fighting for the first grip. Left: two judokas at the start of a trial. The participant on the left is wearing an eye tracker that measures where he is looking (red arrow). 3D positional data were used to measure the distance from the eye tracker to the opponents' head (blue line) and hands (orange dotted lines). Right: Video footage from the eye tracker camera at the start of a trial. The eye tracker records both the scene in front of the participant as well as their own eye movements (top left corner). By overlaying these images, the position is determined where the participant fixated their gaze (indicated by the green cursor).*

4.2.2 Main results

During the fight for the first grip, participants mostly focused their gaze centrally on their opponent's chest. These findings suggest that athletes indeed made use of the chest as a "visual anchor point".

We calculated how wide the visual field would need to be for an athlete to keep the hands of their opponent within view while fixating at the opponent's chest (Figure 5). With a visual field of 20 degrees radius (i.e., the current MIC), an athlete is able to view at least one of the opponent hands 91% of the time, yet both hands were within view only 29% of the time. This means the athlete might

be surprised by an incoming hand outside their visual field 71% of the time, most probably constituting a significant disadvantage in judo. This result suggests that an MIC of 20 degrees visual field is too narrow.

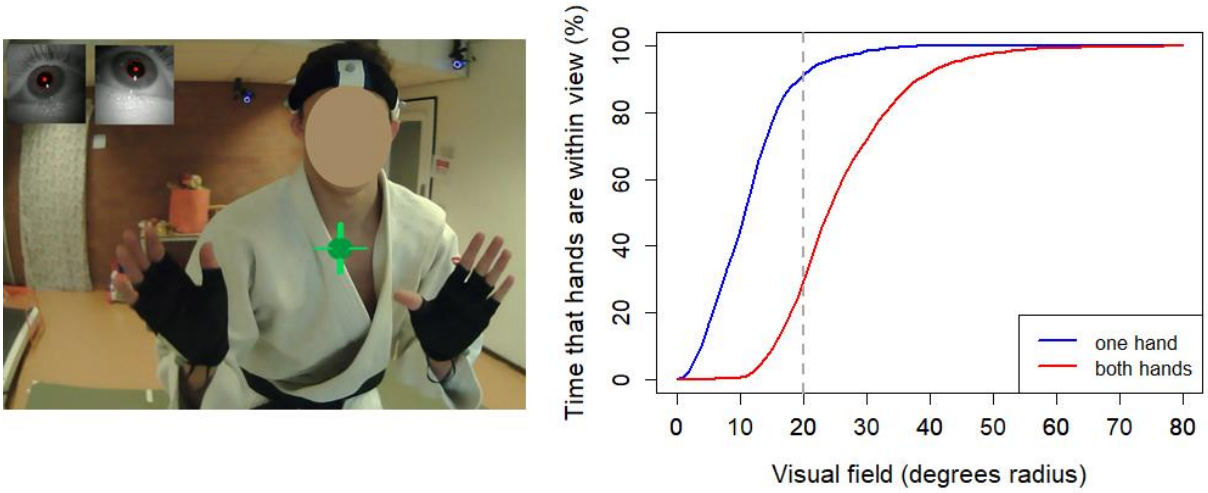


***Figure 5**: Gaze analysis of judokas fighting for the first grip. Left: Image from the video footage of the eye tracker. The green cursor indicates where the judoka fixated their gaze. Right: percentage of time that the hands are within view when fixating centrally on the opponent's chest as a function of the size of the visual field.*

Table 1 shows how the percentage of time in which the hands are visible alters with changes in the visual field. Because the visual field is difficult to assess with greater than 10 degrees accuracy, we examined steps of 10 degrees radius. With a visual field of 40 degrees radius, both hands are visible for 92% of the time during the fight for the first grip. We expect that this would not have a large impact on performance and that an MIC of 40 degrees radius would be too wide. Therefore we suggest a new MIC at a visual field of 30 degrees radius, where at least one hand is visible for 98% of the time and both hands are visible 72% of the time. We expect that athletes with vision loss of at least 30 degrees radius have an impact on their performance when competing in able-sighted judo against fully sighted opponents, and should therefore be classified eligible to compete in VI judo.

	VF radius = 10 deg	**VF radius = 20 deg**	**VF radius = 30 deg**	**VF radius = 40 deg**	**VF radius = 50 deg**
One hand	45%	91%	98%	100%	100%
Both hands	0%	29%	72%	92%	98%

***Table 1**: Percentage of time that the hands are within view when fixating centrally on the opponent's chest. The columns show different sizes of the visual field. The rows show the percentage of time that at least one hand or both hands of the opponent are within view.*

Figure 6 provides an illustration of the field of view for a judoka with a visual field of 20, 30 or 40 degrees radius during the fight for a grip. The figure shows how an athlete views an opponent positioned at 70 cm distance, which we found to be the average position at which athletes position themselves during grip fighting.

***Figure 6**: Illustration of the field of view for judokas with different degrees of visual field loss. The red circle shows the area the judoka can see while fixating centrally at the chest of the opponent. From left to right the images show the field of view for judokas with a visual field of 20, 30 and 40 degrees radius, respectively.*

Two further points are worth noting:

1. Visual field loss is not always circular as it is shown in Figure 6. However, we have assumed that a visual field of 30 degrees radius is relatively similar irrespective of where the field loss occurs. Note that those with central vision loss are likely to qualify to compete on the basis of their loss of visual acuity.
2. A visual field of 30 degrees radius may allow athletes in some sports to see most or all of what they need to see, for instance in shooting or archery because of the large distance to the target. The close nature of combat in judo means that performance is likely to decrease with relatively less loss of visual field.

A manuscript containing the full explanation of the results of this study is in preparation to be submitted to a scientific journal.

Recommendation

Our findings suggest that the current MIC for visual field is too severe, meaning that some athletes are currently excluded from VI judo even though their vision impairment is likely to genuinely decrease performance when competing against fully sighted opponents in judo. We recommend a less-severe MIC for visual field of 30 degrees radius.

5 Sport classes

Under the existing classification system, eligible VI judokas are allocated to one of three sport classes (B1, B2 or B3) even though all athletes compete in a single sport class during competition. According to the expert panel, blind and partially sighted athletes should not compete against each other in the same class. We conducted three studies that all confirmed this expert opinion.

5.1 Impact of simulated blindness on judo performance

5.1.1 Aim and method

The current one-class system appears to be based at least in part on the assumption that judokas do not need vision to guide their actions as long as the grip is in place at the start of the bout. The aim of this study was to test this assumption by determining whether vision has any impact on judo performance when both athletes start the match with their grip in place (i.e., under VI judo conditions). Twenty-four able-sighted, talented youth judokas competed in three-minute practice fights in sighted and blindfolded conditions. Each participant fought the same opponent twice (Figure

7): once sighted (with the opponent blindfolded) and once blindfolded (with the opponent sighted). Performance was measured by counting the number of scoring throws within a three-minute fight (contrary to a regular judo contest, fights did not stop after a full point or *ippon* was scored, but continued for the full three minutes).

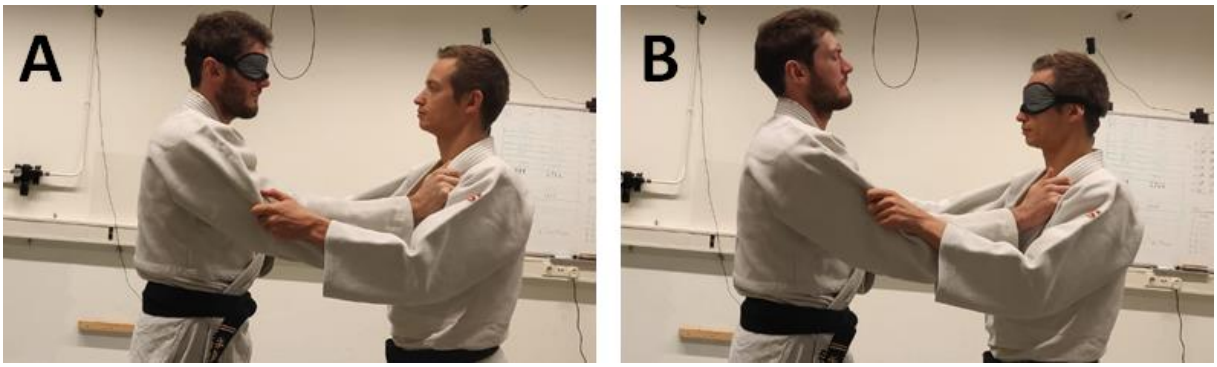


Figure 7: *Illustration of the two conditions in which the judokas competed. Judokas fought against the same opponent twice. In the first round, one judoka competed blindfolded while the other was fully sighted (A). In the next round, the other judoka was blindfolded and the first judoka competed fully sighted (B).*

5.1.2 Main results

We found a significant disadvantage for blindfolded judokas when fighting against sighted opponents. Judokas managed to score more often in the sighted compared to the blindfolded condition despite fighting the same opponent (Figure 8). Blindfolded judokas were not completely helpless; even without vision, they were still able to throw their sighted opponents. However, fighting with access to visual information clearly led to superior performance. As we compared the same athlete fighting with and without vision, decreased performance could not be attributed to changes in training history or talent. This study therefore showed that visual function provides an advantage to judokas even when starting a match on the grip. It may therefore not be readily assumed that all VI judokas are able to compete equitably within one sport class, regardless of their degree of vision impairment. Yet additional studies were needed to provide recommendations on how many classes are warranted and how these classes should be defined.

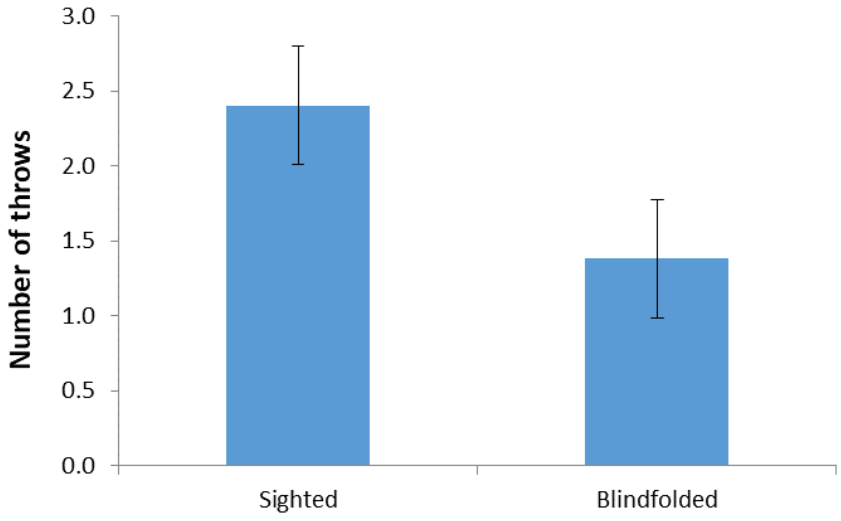


Figure 8: *Number of scoring throws made by judokas in the sighted and blindfolded conditions.*

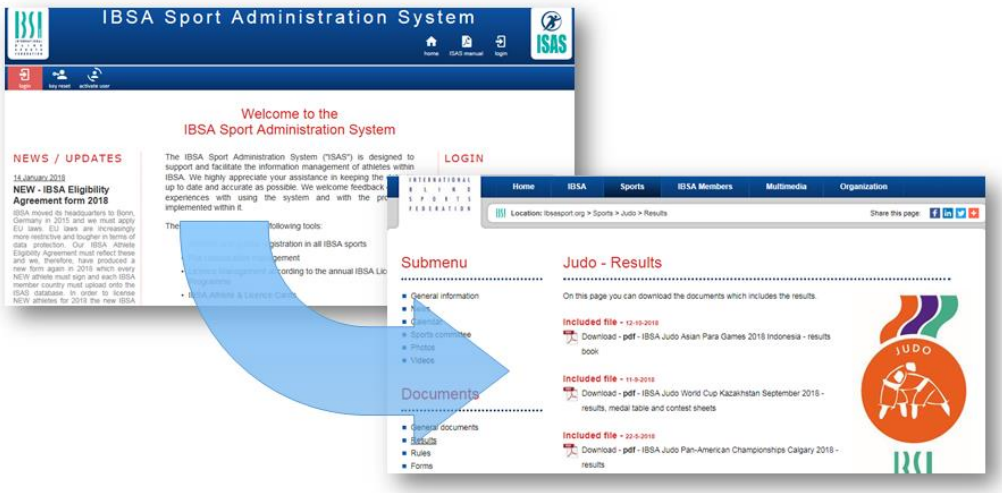
The full explanation of the results can be found here:

> Krabben, K. J., van der Kamp, J., & Mann, D. L. (2018). Fight without sight: The contribution of vision to judo performance. Psychology of Sport and Exercise, 37, 157-163. https://doi.org/10.1016/j.psychsport.2017.08.004

5.2 Relationship between current classification data and competition results

5.2.1 Aim and method

In this study we compared existing classification data to the outcomes of international VI judo competitions held between 2012 and 2018. Data on the visual acuity and visual field of competitors measured during classification were obtained from the administration system of the International Blinds Sports Federation (IBSA). All data were anonymised before further processing. Performance was determined by calculating the percentage of matches won by each athlete across the different competitions they fought in. We used machine learning (decision tree analyses) to determine whether the data supported splitting VI judo into multiple classes, and if so, at what level of impairment the split(s) should occur. To test the stability of our outcomes, we replicated the decision tree analysis 10,000 times, each time using a slight variation of our original data sample as input. This approach is known as *bootstrapping* and helps to estimate the accuracy of results.



5.2.2 Main results

We gathered classification and competition data for 296 judokas who all competed in multiple competitions between 2012 and 2018. For nearly all of these athletes (99.3%), a measure of visual acuity could be retrieved from their classification data. Visual acuity was significantly associated with judo performance, with athletes with worse visual acuity losing more of their fights. Visual acuity was not evenly distributed (see Figure 9). Very few athletes competed with a visual acuity value between 2.5 and 3.5 logMAR, most probably because it is relatively rare to record visual acuity between these levels.

Visual field was measured in only 25 (8.4%) of the judokas during classification. We found no relationship between visual field and judo performance, but this is possibly due to the low number of judokas who have their visual field measured. On the basis of this information, separate classes would not be required due to differences in the size of the visual field.

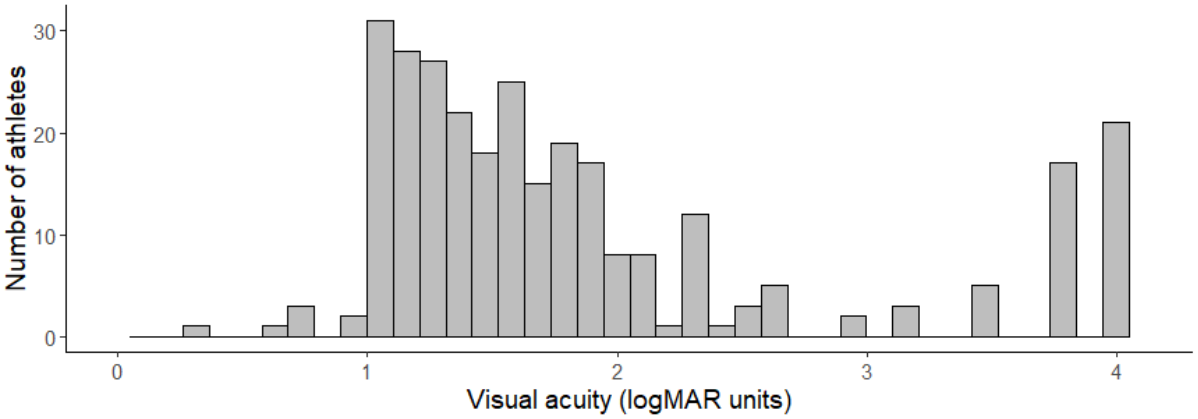


Figure 9*: Distribution of visual acuity of judokas included in the dataset. Visual acuity was not evenly distributed: most judokas either had a visual acuity better (i.e., lower) than 2.5 logMAR, or they were classified as either "light perception" or "no light perception" (designated 3.75 and 4.0 logMAR, respectively).*

On the basis of their win rates, our main statistical analysis suggested to split the data into two groups: (1) one for athletes with a visual acuity of 2.4 logMAR or better (average win ratio = 51%); and (2) one for athletes with a visual acuity worse than 2.4 logMAR (average win ratio = 27%).

The bootstrap assessment consistently confirmed a split into two groups, but showed considerable variability in the cut-off point. Indeed, the decision trees split the data at various points between 2.0 to 3.5 logMAR depending on slight variations in the data sample. Because there were only a limited number of judokas within that acuity range, the individual performance level of these judokas had a large impact on the outcome of the analysis. Therefore, it remained unclear exactly at which point the cut-off should occur, and whether other tests of vision might be a better way to measure impairment in judo.

A manuscript containing the full explanation of these results is currently under review for publication in the *Journal of Sport Sciences* special issue on evidence-based classification in Paralympic sports.

5.2.3 Additional analyses to set sport-class criteria

The findings of this study clearly suggested that better sighted judokas are advantaged within the current system and therefore warrant a split into separate sport classes. Yet the results are inconclusive where to make this split. Statistical analyses suggested an optimal cut-off between 2.0 and 3.5 logMAR, but the accuracy was limited because of the relatively low number of judokas within this range. We therefore conducted two follow-up analyses to gain additional understanding about the impact of impairment on performance for judokas with visual acuity between 2.0 and 3.5 logMAR.

5.2.3.1 Match level analyses

We analysed the outcome of individual matches between three groups of judokas with different degrees of vision impairment:

GROUP 1. Judokas with visual acuity between 1.3 logMAR (our suggested new MIC) and 2.0 logMAR;
GROUP 2. Judokas with visual acuity between 2.0 and 3.5 logMAR;
GROUP 3. Judokas with visual acuity worse than 3.5 logMAR (i.e., light perception or no light perception).

Table 2 shows the results of this analysis. As expected, we found a large impact of impairment on performance when the partially sighted judokas in Group 1 competed against the blind judokas in Group 3: 205 out of 267 matches (77%) were won by the better sighted judoka (Table 2.1). This further supports the need for separate competitions for these two groups of judokas. Judokas in Group 2 seemed to fall in between: when fighting against the better sighted judoka from Group 1, judokas in Group 2 lost 204 out of 340 of their matches (60%) and so seemed to have a slight disadvantage. Yet when fighting against blind opponents from Group 3, the Group 2 judokas won 43 out of the 63 fights (68%) and therefore seemed to hold an advantage on the basis of their better visual function (Table 2.2).

The notion that judokas with visual acuity between 2.0 and 3.5 logMAR fall in between the other groups justifies the question of whether these judokas would actually warrant their own sport class. We investigated whether the Judokas in Group 2 required their own distinct class or whether a split should be made that allocates some athletes in this group to Group 1 and others to Group 3.

We did not find a clear relationship between impairment and performance within the athletes in Group 2 who both had a visual acuity between 2.1 and 3.5 logMAR: the better sighted judoka in these matchups won 19 out of the 35 fights (54%; Table 2.2). A three class system indeed therefore has some merit, yet additional classes should always reduce the impact of impairment on performance for athletes competing together. Classification should therefore seek to offer legitimate competition using a minimum of sport classes, offering maximal competitiveness: if the impact of impairment on the outcome of competition can be minimised to the same extent using two rather than three sport classes, a two-class system should be put in place.

Table 2.3 revealed that judokas with visual acuity between 2.6 and 3.5 logMAR seem to compete evenly against the blind judokas in Group 3, winning exactly 50% of their fights against these opponents. In contrast, judokas with visual acuity between 2.1 and 2.5 logMAR won the majority of their fights against the Group 3 judokas (79%), suggesting that they should compete in a different class (Table 2.3). Judokas with a VA between 2.1 and 2.5 logMAR do though seem able to compete relatively evenly against their sighted opponents in Group 1, with the Group 1 judokas winning 123 out of 214 fights (57%). This 57% win rate for the better sighted athlete is only marginally worse than the 55% found within a possible third class for Group 2 athletes. The benefits of a third class in terms of reduced impact of impairment on the outcome of competition therefore does not seem to outweigh the costs of reduced competitiveness compared to a two class system. This analysis thus suggests a two class system with an optimal cut-off point at 2.5 logMAR where those with visual acuity worse than 2.5 logMAR would compete in a separate class to those with 2.5 logMAR or better (Table 2.5).

	Best sighted VA		*Worst sighted VA*		*Match statistics*		
	Min	Max	Min	Max	best sighted wins	matches played	win ratio
1	1,3	2,0	3,7	4,0	205	267	77%
	1,3	2,0	1,3	2,0	310	626	50%
	3,7	4,0	3,7	4,0	5	9	56%
2	1,3	2,0	2,1	3,5	204	340	60%
	2,1	3,5	3,7	4,0	43	63	68%
	2,1	3,5	2,1	3,5	19	35	54%
3	2,1	2,1	3,7	4,0	9	11	82%
	2,3	2,3	3,7	4,0	15	19	79%
	2,5	2,5	3,7	4,0	7	7	100%
	2,6	2,6	3,7	4,0	2	5	40%
	2,7	2,9	3,7	4,0	2	5	40%
	3,2	3,5	3,7	4,0	8	14	57%
	2,1	2,5	3,7	4,0	31	39	79%
	2,6	3,5	3,7	4,0	12	24	50%
4	1,3	2,0	2,1	2,1	33	56	59%
	1,3	2,0	2,3	2,3	66	117	56%
	1,3	2,0	2,5	2,5	12	24	50%
	1,3	2,0	2,6	2,6	18	28	64%
	1,3	2,0	2,7	2,9	11	16	69%
	1,3	2,0	3,2	3,5	52	82	63%
	1,3	2,0	2,1	2,5	123	214	57%
	1,3	2,0	2,6	3,5	81	126	64%
5	1,3	2,5	2,6	4,0	324	451	72%
	1,3	2,5	1,3	2,5	441	851	52%
	2,6	4,0	2,6	4,0	21	38	55%

Table 2: *Match level analysis of the impact of visual acuity (VA) levels on the outcome of the match. In five steps, the analysis suggests a split into two sport classes at 2.5 logMAR would minimise the impact of impairment on the outcome of competition.*

5.2.3.2 Technical profiles

To provide additional insights to further investigate the new sport class criteria, we compared the type of throwing techniques most regularly applied by judokas with different amounts of vision impairment during the Rio 2016 Paralympic Games. Data for these analyses were obtained from the official Results Book of the event.

We found that the degree of vision impairment not only influenced the *number* of scoring throws judokas made during competition, but it also influenced the *type* of throwing techniques they favoured (see Figure 10). Blind athletes predominantly favoured sacrifice throws, which are techniques whereby the attacking judoka drops themselves on their back first (i.e., "sacrifices" oneself) in order to execute the throw. Sighted judokas showed more variability in the type of techniques they applied. Leg throws were particularly used more frequently by sighted judokas than those with higher vision loss.

The technical profiles of athletes with a visual acuity between 2.1 and 2.3 logMAR appear more comparable to those of partially sighted athletes. In particular, many of these athletes were able to successfully execute leg throws. The technical profiles of athletes with a visual acuity of 2.9 or 3.2 logMAR were more comparable to those of blind athletes. In particular, they used more sacrifice throws and less leg throws. Unfortunately, no athletes were included with a visual acuity of 2.4 – 2.8 logMAR. Still, this analysis provided further support for a two class system in VI judo.

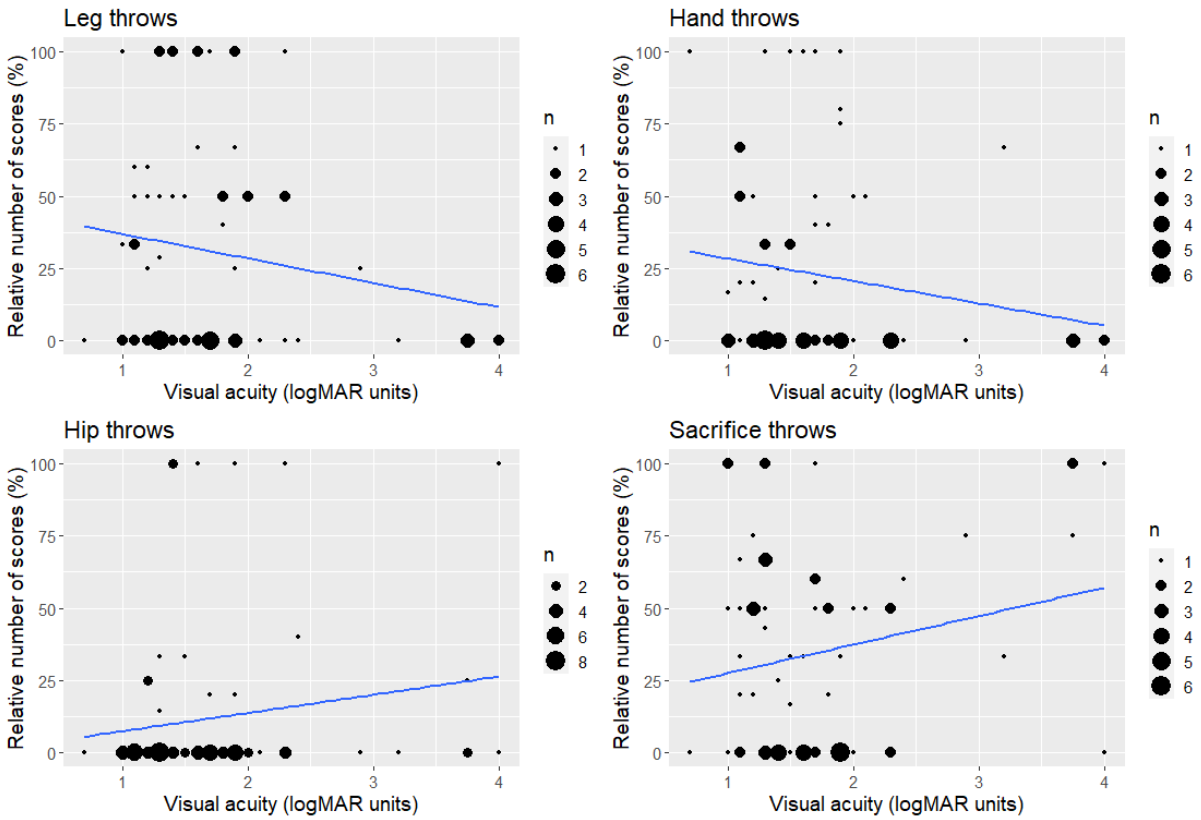


Figure 10: *Relationship between visual acuity and relative number of scores using different types of technique. Higher visual acuity scores represent worse visual function. Each dot represents one or multiple judokas, with larger dots representing more judokas.*

5.2.3.3 Conclusions

The additional analyses suggest that athletes with a visual acuity between 2.0 and 3.5 logMAR do not necessarily represent a distinct and homogeneous third class. Instead, the better sighted athletes in this range seem to behave and perform more similarly to athletes with visual acuity better than 2.0 logMAR, whereas the worse sighted athletes seem more comparable to blind athletes (i.e., those with or without light perception). Additional match level analyses, although limited in their statistical power, suggest a cut-off at approximately 2.5 logMAR.

Recommendation

Within the existing classification system there is a clear disadvantage for athletes with severe impairment who compete against partially sighted opponents. We recommend to split VI judo competition into two sport classes, separating competition into one class for partially sighted athletes with visual acuity up to and including 2.5 logMAR, and a second class for athletes with visual acuity worse than 2.5 logMAR.

5.3 Relationship between other visual functions and judo performance

5.3.1 Aim and method

The aim of this study was to establish the best combination of measures of vision to include in classification for VI judo. We visited two continental VI judo championships: the 2017 IBSA European Judo Championships in Walsall (United Kingdom) and the 2018 IBSA Judo Pan-American Championships in Calgary (Canada). During these events, we recruited 52 VI judokas. Our thanks to all those judokas who took part. The visual function of these judokas was tested using our own battery of vision tests, which consisted of seven different measures of vision (visual acuity, visual field, contrast sensitivity, motion perception, visual search, depth perception and light sensitivity). In agreement with recommendations from both our expert panel and the Joint IPC & IBSA Position Stand on Classification for Athletes with Vision Impairment, we measured visual function in this study using both eyes together wherever possible. Because visual acuity is currently measured with each eye separately during classification, we measured visual acuity both with one eye and with both eyes together. This allowed us to compare the results obtained in this study with analyses based on classification data. Performance data were gathered from all international competitions that the athletes participated in two years before and after vision testing.

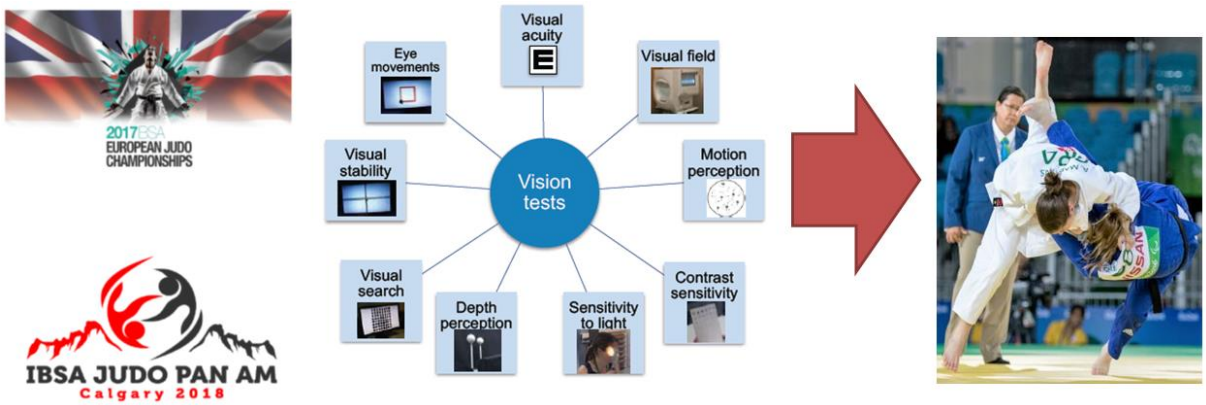


***Figure 11**: Setup of the study. Participants were recruited at the 2017 European Championships and 2018 Pan-American Championships. Visual function was assessed using our vision test battery and related to judo performance.*

5.3.2 Main results

Visual acuity correlated more strongly with performance than any of the other visual functions. Machine learning (decision tree) analysis suggested that the judokas could be split into two groups: (1) one for athletes with a visual acuity of 2.6 logMAR or better (average win ratio = 40%); and (2) one for athletes with a visual acuity worse than 2.6 logMAR (average win ratio = 25%). These results align well with those reported in the previous section, confirming the need for (at least) two classes in VI judo. We found only minimal differences between the visual acuity measured when testing both eyes together rather than when testing with the best eye only (an average improvement of 0.04 logMAR units with both eyes together). This showed that the results from this study can be directly compared to those reported in the previous section when testing one eye only.

Visual acuity correlated strongly to all other visual functions. After controlling for the relationship between visual acuity and performance, there was no relationship between any of the other tests of visual function and the performance of the judokas (Figure 11). This suggests that the inclusion of additional tests of visual function does not improve the ability to place judokas into fairer classes. No other tests of visual function besides visual acuity are therefore required to determine in which sport class a judoka should compete. This does not mean that other measures of vision such as contrast sensitivity and motion perception are not related to performance in judo, rather more simply that if an athlete has poor visual acuity then those other measures of visual function tend to be poor also.

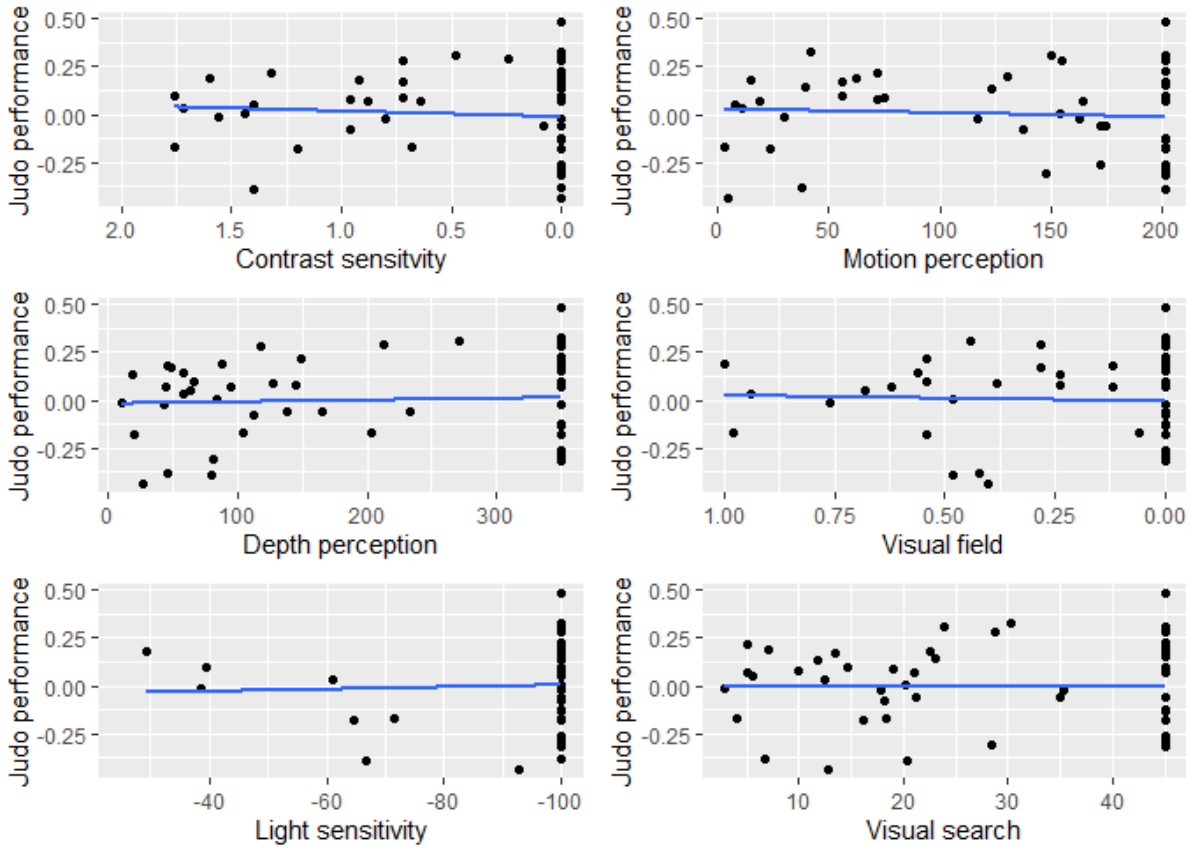


Figure 12: *Correlations between different visual functions and performance after controlling for visual acuity. Each dot represents a single VI judoka. All graphs show a measure of visual function on the x-axis, with poorer vision to the right. The Y-axis shows the difference between the judokas' actual performance in competition and their expected performance on the basis of their visual acuity. Positive values represent above-expected performance and negative values represent below-expected performance.*

We presented the results of this study at the VISTA 2019 Conference in Amsterdam. The slides of this presentation can be found here: https://www.paralympic.org/sites/default/files/2019-11/Vista%202019_74_Krabben.pdf. A manuscript containing the full explanation of the results is in preparation to be submitted to a scientific journal.

Recommendation

The inclusion of additional tests of visual function does not improve the fairness of classification for VI judo. No other tests of visual function besides visual acuity are required to determine in which sport class a judoka should compete. Visual field is required only for the determination of eligibility to compete (i.e., for the minimum impairment criteria).

6 Recommendations

Based on the research results, we come to the following recommendations for a new evidence-based system of classification for VI judo.

6.1 Minimum impairment criteria

6.1.1 Recommendations

We recommend to classify judokas as eligible to compete in VI judo when they meet one the following minimum impairment criteria:

- Binocular visual acuity equal to or worse than 1.3 logMAR;
- Binocular visual field of 30 degrees radius or less.

6.1.2 Additional considerations

The recommended MIC for visual acuity is based on a balance between sensitivity (including those who should be included) and specificity (excluding those who should be excluded). We found that this balance is optimal between 1.3 and 1.5 logMAR. Given the uncertainty, we recommend to set a new MIC for visual acuity at 1.3 logMAR to minimise the risk of falsely excluding judokas who do have an impairment to their performance.

We identified the number of judokas who are currently eligible to compete, but would no longer be eligible under the recommended changes to the minimum impairment criteria for visual acuity. Using the classification data collected for the study described in section 5.2, we examined the most recent classification of all ISAS registered judokas who were classified at least once between 2012 and 2018. Out of a total of 561 judokas, 111 (19.8%) were classified as eligible to compete with a visual acuity between 1.0 and 1.2 logMAR (though the number may vary slightly because that was tested with monocular rather than binocular visual acuity). With the recommended new MIC of 1.3 logMAR, these judokas would be classified as not eligible to compete (unless they still qualify to compete on the basis of an impaired visual field). Because most judokas currently qualify to compete on the basis of visual acuity, we are not able to estimate the impact of the recommended changes on the number of judokas who will qualify to compete on the basis of an impaired visual field. We are also unable to estimate how many VI judokas will additionally qualify to compete on the basis of the suggested new MIC for visual field. Another point to consider is that changes in classification criteria might also draw new judokas to the sport, for instance athletes who previously felt they were disadvantaged in VI judo when fighting better sighted opponents (particularly those in the current B1 class with high support needs).

6.2 Sport class criteria

6.2.1 Recommendations

We recommend to split VI judo into two sport classes during competition: one for all eligible judokas with a visual acuity up to and including 2.5 logMAR; and a second class for athletes with visual acuity worse than 2.5 logMAR.

6.2.2 Additional considerations

The research results clearly show an advantage for partially sighted judokas when fighting against functionally blind opponents. Yet it turned out to be not straightforward to determine how many sport classes are warranted and where to draw the lines between those classes. This was especially difficult because of the relatively low number of athletes around the suggested cut-off point of 2.5 logMAR. In section 5.2.3 we even considered the possibility of a third sport class specifically for athletes with a visual acuity between 2.0 to 3.5 logMAR. Based on the data available, we expect only marginal benefits of a third sport class in terms of further reducing the impact of impairment on the outcome of competition and therefore suggest a two-class system. We do recommend careful and accurate assessment of VA in those with severe vision impairment in combination with continued monitoring of their performance in future VI judo competitions.

We also recommend IBSA to take a position on the potential use of blindfolding in the class for those with most severe impairment because it could provide a means of equalising vision during competition and reducing concerns about intentional misrepresentation. The panel members in our expert consultation could not agree on the use of blindfolds for VI judo. A small majority believed that blindfolding might improve the fairness of VI judo competition, yet there were also concerns that blindfolding could be too dangerous or impractical in judo. The expert panel also rated blindfolding as the least effective of eight potential measures to reduce the incidence of intentional misrepresentation.

6.3 Additional recommendations

In our expert consultation, the panel members discussed some additional issues related to current classification procedures.

6.3.1 Best optical correction?

Visual function is currently assessed during classification while athletes wear the best possible optical correction. Our panel agreed that the current procedure was appropriate, irrespective of whether or not the correction could be worn on the mat during competition. The main comment was that an athlete might still benefit from using optical correction away from competition (i.e., by observing others demonstrating techniques to them in training, or to study fights of their opponents).

6.3.2 Classification centres

Classification is currently conducted at a competition venue or a local ophthalmology/optometry clinic or hospital prior to the start of competition. Some panellists raised concerns about this approach due to: (i) differences in testing conditions across the different competition events, and (ii) not enough time being available for classifiers to fully examine visual function during classification prior to a competition, leaving classifiers to rely on medical documents provided by the athletes which are of various standards. One potential solution raised by panellists was the establishment of “classification centres” where athlete evaluation would be conducted, rather than classifiers traveling to competition venues. At these centres, both the medical assessment to establish the athlete’s medical condition, as well as the tests of visual function could be conducted (subject to meeting the requirements of the IPC Athlete Classification Code). The panel reached consensus that

they would favour the use of centralised classification centres over the current method of classification at competition. The main consideration was that classification centres would increase the quality and credibility of classification, although some panellists objected because of the additional time and (financial) resources required to travel to these centres.

6.3.3 Intentional misrepresentation

Athletes who deliberately underperform on classification tests are guilty of the intentional misrepresentation (IM) of their abilities. The expert panel expressed serious concerns about the threat of IM to the fairness of competition, which is an issue of broader concern across VI sports. It would therefore seem worthwhile for both classification researchers and governing bodies of VI sports to consider measures that would prevent the incidence of IM and to increase the trust of the VI sports community in their classification systems. The highest priority of our panel was to introduce less subjective testing, because current methods rely on athletes to provide their best effort and honest answers.

The Research and Development Centre for the Classification of Athletes with Vision Impairment is involved in several projects that aim to develop methods to detect IM in VI sports. One approach to increase objectivity in classification is to take into account the consistency of test performance, which may hold promise as an indicator of whether or not the athlete provided their best effort and honest answers. To test this experimentally, we trained participants to cheat on a visual acuity test. We found that although participants were able to successfully cheat on the test, their answers were significantly more variable when cheating than when providing genuine answers. The findings of this study have been incorporated into classifier training to make classifiers aware that a large variability in answers during testing is a possible indication of IM. Classifiers are now allowed to use those results to make a judgement of whether an athlete is providing reliable results during classification.

Other projects on the detection of IM involve the use of gaze tracking (using pupil detection software to measure where someone is looking during a classification test), electrophysiological testing (measuring the neurological response to visual stimuli) and an assessment of postural responses (head sway) when presented with a moving scene in a virtual reality environment. Some of these projects show promising results, but are not ready to be implemented yet. For example, we found that postural sway can be successfully detected in a virtual reality environment even when participants were asked to intentionally suppress their response. Yet one out of four participants did not show the expected automated response even under normal conditions. Further understanding why some people respond differently than others is needed before this test could be successfully implemented to detect IM during classification, otherwise one out of four athletes might be wrongfully accused of IM. The Research and Development Centre is fully aware of the great concern for the threat of IM in judo as well as other VI sports, and will continue research efforts to develop new methods to better detect IM during classification. This is a major challenge because almost all existing tests of vision rely on the honest subjective responses of participants.