Risk compensation behaviour is present in Historical European Martial Arts and can oppose a risk for the effectiveness of preventive measures

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Risk compensation behaviour is present in Historical European Martial Arts and can oppose a risk for the effectiveness of preventive measures.

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Abstract –

Background: Prevention is the first line of defence in sport related injuries. To minimalize the chances of injuries, sports use preventive measures such as rules, settings and protective equipment. Risk compensation behaviour is the combination and compilation of behaviours that are the result adapted behaviour by wearing protective equipment or other preventive measures. **Aim**: The aim if this study is to investigate whether risk compensation behaviour is triggered by wearing more protective equipment in Historical European Martial Arts. **Material and methods**: 30 fencers (15 duos) competed in 2 combat settings one while wearing a full set of protective equipment, the other while wearing minimal protective equipment. The fencers fought 2 rounds against an age and experienced matched partner in both of the settings. After the fencing bout a series of questionnaires was conducted in order to map risk compensation behaviour. **Conclusion**: Risk compensation behaviour is present in Historical European Martial Arts and developers of protective equipment and tournament managers should take it into account in the development of protective measures.

Keywords : Historical fencing, Historical European Martial Arts, Risk compensation behaviour, injury prevention.

Introduction:

Historical European Martial Arts (HEMA) sometimes recalled as Historical Fencing (HF) are a mix of historical combat systems and martial art that were developed in Europe and can be seen as the European counterpart of many Asian Martial arts. It consists of a variety of armed and unarmed or armoured and unarmoured combat techniques with a variety of weapons ranging from dagger to one-handed arming sword, one-handed rapier, one-handed long knife (all with or without shield, buckler or dagger) to longsword, great sword, polearms and others (Jaquet, 2015; Jaquet & Walczac, 2015; Jaquet et al, 2015, Wauters & Vantiggelen, 2015; Wauters, 2023a, Wauters, 2023b, Wauters & ter Mors, 2023). They all can be combined with close combat techniques such as grappling, striking and kicking. These techniques are recorded in historical manuscripts or books at the time, are now taught all over the world.

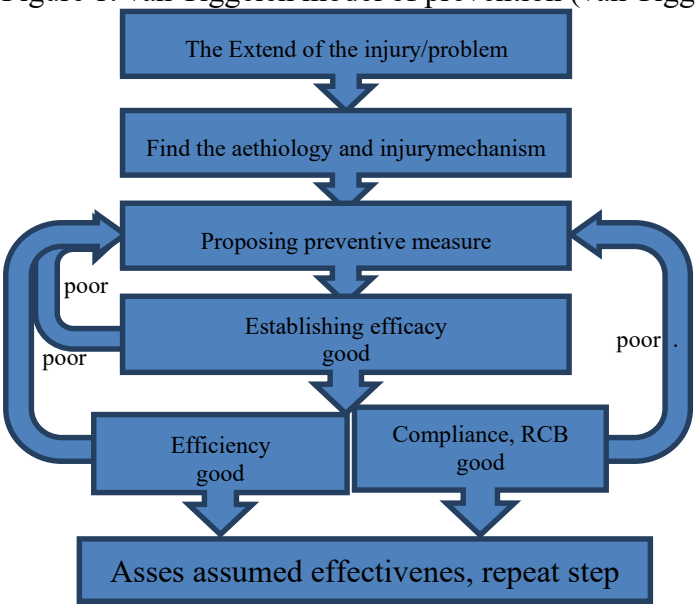
Martial arts in general can be divided on content in armed or unarmed arts, striking, grappling or hybrid forms (Critchley, et al 2019; Lystad et al, 2015; Ziaee, et al, 2015) or on impact/contact form in non, light, medium or full contact forms (Critchley, et al 2019; Lystad et al, 2015; Ziaee, et al, 2015). HEMA is a hybrid martial art that involves a variety of

weapons and includes grappling and striking techniques. Some styles are armoured. Unlike historical re-enactment and bohurt, Historical Fencing or Historical European Martial Arts uses modern protective equipment like modern fencing helmets and jackets rather than historical clothing. There are non-contact, light, medium and full contact forms. Regarding protective equipment there can be a differentiation within the disciplines. Non-equipment fencing is fencing without any protective equipment (NEF) and generally is lighter in intensity and contact. Minimal equipment fencing (MEF) is fencing with the minimal protection of fencing helmet, throat protection and light gloves. It allows more and intensive contact than non-equipment fencing. Full equipment fencing (FEF) is fencing with complete protection set such as in full contact sparring and tournament fencing. In terms technical aspects actions and intensities, HEMA is closer related to judo, sambo and sumo for its wrestling disciplines and kenjutsu for its fencing disciplines, rather than to modern Olympic fencing with lighter and slimmer sword blades(Murgu,2006, Schultzel et al, 2016; Wauters; 2023a; Wauters, 2023b, Wauters & ter Mors, 2023; Weinmann, 2013).

Every sport, although some more than others are prone for injuries (Finch, 2006; McBain,2011a; McBain,2011b; Van tiggelen et al, 2008). So are Historical European Martial Arts (Wauters & Van tiggelen, 2016). Van tiggelen et al proposed a model for the development of protective equipment and preventive measures in 2008 (Figure 1). It is based on, but more elaborate than, the 1992 model of Van Mechelen. Prevention is the first line of defence against injuries. After first understanding the aetiology (origin of the problem) and epidemiology (frequencies et cet.) of a problem, preventive strategies and measures can be made. When a measure is made its efficacy (how well it protects), efficiency (easy it is to apply the measure eg. Easy to wear, et cet), compliance and risk compensation can be tested, on order to feedback the preventive measure and have to be mapped in order to check for its effectiveness (Van tiggelen etal.2008). For example, in case of head injuries, head impact forces are one of the causes (ethology/injury mechanism and epidemiology). For the decrease of impact force, a helmet can be worn (preventive measure). Head gear have been proven to diminish the impact force (efficacy) (Verhaegen et al., 2010; Windt,2016) but are sometimes not sufficient (lack of efficacy). New models are very easy to ware (efficiency) and athletes do wear one (compliance) and if athletes do not alter their behaviour to it (risk compensation behaviour) this is a very effective measure against head trauma. Yet some do not consider it ecstatically or find it annoying and chose not to wear one or some tournaments do not allow it at all (compliance) or athletes alter their behaviour to it since they have the feeling that they or their adversary are safe and they present more risk full behaviour and risk compensation behaviour (RCB).

RCB is any behaviour that is influenced or altered by the presence of protective equipment. When the preventive measure or protective equipment is present, people tend to feel more safe and better protected. This might alter their behaviour, by showing more risk full actions. It is proven in different sports, (Finch, 2006; Van tiggelen, 2008) including Martial Arts (Crichley et al, 2015) and suspicions in HF (Wauters & Van tiggelen, 2016) but has a lot of contributing factors.

Figure 1: van Tiggelen model of prevention (van Tiggelen et al, 2008)



This study fits in a larger project around injury prevention in HEMA and HF and fits in the final phase of the prevention model suggested by Van Tiggelen et al (2008). The aim is to investigate whether risk compensation behaviour (RCB) might be present in Historical European Martial Arts, in order to estimate it impact in preventive measures and the development of protective equipment.

Material and methods

Recruiting

For this experiment people were recruited by contacting several Historical Fencings (HF) schools and clubs in the Netherlands and Belgium. Management, coaches and trainers of the clubs were contacted with an invitational letter for their participation in the project and whether they were willing to share the invitation with the members of their school or club.

There were a total of 35 responses. 5 were declined or excluded for either, having injuries (N=2), less than one year of experience (N=2), or feeling sick at time of the testing (N=1). Out of these there were made 15 experience matched couples. The flowchart is presented in figure 2.

Setup

The experiment was done in 2 days. 7 couples were tested one day, 8 the other. On day 1, the present fencers first fenced in minimal equipment fencing- setting (MEF) and, after a 1.5-2 hours rest, they fenced the same opponent in a full equipment fencing setting (FEF). The fencers that participated on day 2, first fought in FEF and then in MEF. This was done in order to minimalize learning experience bias. Each couple did his both fencing bouts one day The flowchart is presented in figure 3.

Figure 2: Flowchart of recruitment

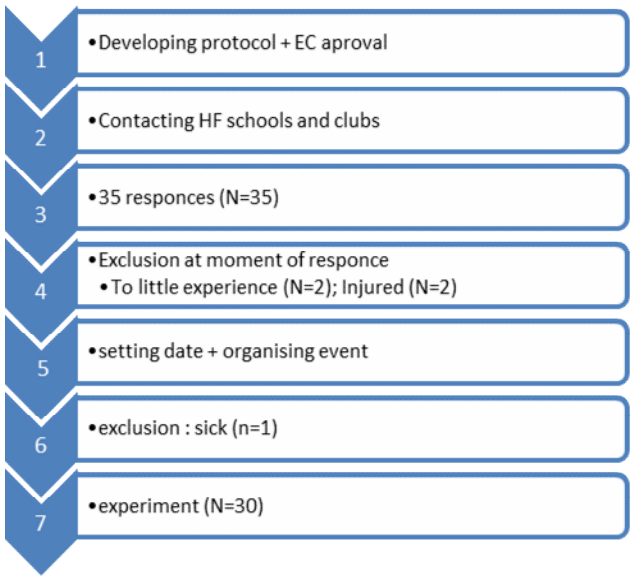
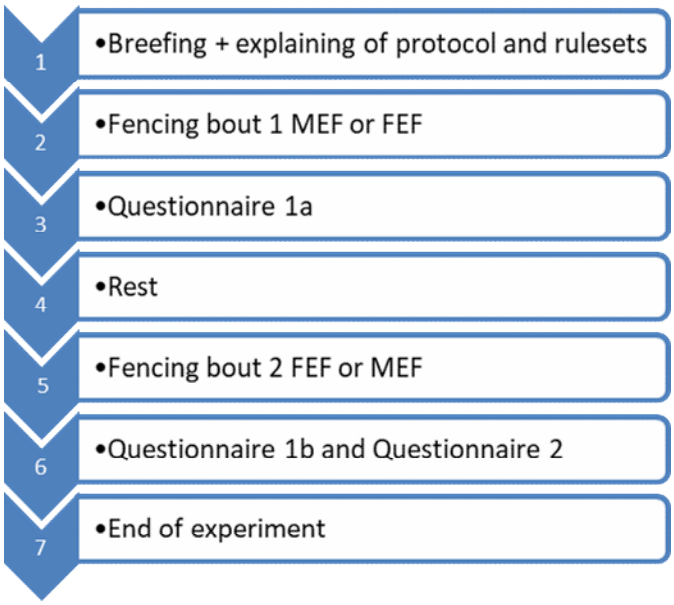


Figure 3: Flowchart of protocol



Fencers were, as much as possible, matched both by age and experience. They were briefed about the goal, purpose, risks, and protocol of the study. They were also, as in a real tournament asked to win each fencing bout. Giving details about risk compensation behaviour were kept to a minimum order not to bias the fencers.

Fencers were allowed to do a warmup according to their needs and habits. After the warmup the first fencing bout started. Each couple fenced 2 times with a break of 1.5-2 hours. Rules for both bouts were the same and are comparable to many tournament settings: one round of 3 minutes, or until one of the fencers reached 15 points. The only valid target was the head, resulting in 2 points. Each time the fencer hits the opponent on the head he gains two points. Grappling, disarms and one-handed strikes were not allowed. Unauthorised actions lead to a warning (1st time) or deduction in points (minus 1 point after the first warning). This setting was used in order to comply with most tournament settings.

Used protective equipment

- Full equipment bout: Helmet + back of the neck protection, throat protector, heavy fencing jacked, heavy fencing gloves, heavy elbow protection, heavy knee protection, groin protection, heavy shin protection, forearm protection (Figure 4a).
- Minimal equipment bout: Helmet + back of the neck protection, throat protector, medium fencing gloves, very light elbow and knee protection (Figure 4b).

Figure 4: Equipment: Full Equipment Fencing (FEF, Left). Medium Equipment Fencing, (MEF, right)

Questionnaires

After each bout a first questionnaire (Questionnaire 1a) was filled in, questioning the bout that the fencers just fought. These questions were regarding the used force and power in thrusts and strikes, the perceived physical and mental intensity, the ability to use proper techniques and proper tactics and were rated on a 0 to 10 scale. 0 meaning no force/no physical exhaustion/no metal exhaustion/no ability to execute proper techniques and tactics. The first set of questions within this questionnaire was regarding the fencers own fencing. The second set were the same questions, but fencer was asked to rate the opponents fencing. Thus, both fencers scored themselves as well as they scored the opponent.

After the last bout the first questionnaire was repeated (Questionnaire 1b) and a second questionnaire (Questionnaire 2) was filled. In this second questionnaire the same questions were asked to rate but now on -5 to +5 scale. the answer -5 strongly favoured minimal equipment fencing and + 5 favoured full equipment fencing. 0 was neutral.

Variables and tests

The variables that were used are the following.
Fencer related variables:

- Age
- Years of Hema experience
- Years of experience in fencing with minimal equipment.

First questionnaire (Q1a and Q1b): Fencing related variables(1): 0-10 scale: These were filled in after each fencing bout (MEF and FEF).

- Own perceived and used force
- Perceived force of the adversary
- Own perceived physical intensity
- Perceived intensity of the adversary
- Own perceived mental intensity
- Own perceived tactical variation
- Perceived tactical variation of the adversary

- Own perceived technical variation
- Perceived technical variation of the adversary

Second questionnaire (Q2): Fencing related variables(2): -5 to +5 scale: These were filled in only after the last fencing bout.

- Own perceived and used force
- Own perceived physical intensity
- Own used tactics
- Own used techniques
- Own metal intensity and concentration

Statistical test

The following tests were conducted:

- Descriptive statistics: age, years of experience in Hema, hours of training, hours of training in MEF.
- Normal distribution test: every beforementioned variable.
- Paired testing: Fencing variables (1): parametric or non-parametric tests were chosen accordingly to the normal distribution.
- One sample test: fencing variables (2): test value was set on Zero (0).

Statistical significance was set on 0.95.

Ethics

This research was approved by the ethical committee of the University of Ghent. A written informed consent was obtained by all participants.

Figure 5: Fencing: Full Equipment fencing, left (FEF).Medium Equipment Fencing, right (MEF)

Results

Descriptive statistics and Normal distribution

The descriptive statistics are written in table 1. There were only had male participants with a mean age of 30.27 (+-7.58 sd.) with a minimum age of 21 up to a maximum of 56 of age. In case of years of experience, with a mean of 4.55 years (2.56 sd.) with a minimum of 1 year and a maximum of 10 years.

Table 1: Descriptive statistics

	Mean	Med.	Std. Dev.	Min	Max
Age	30,27	28	7,58	21	56
Years exp Hema	4,55	5	2,56	1	10
Training hours	4,92	5	2,12	1	10
MEF training hours	1	0,75	0,5	0,5	5

Injuries

Injuries are listed in table 2. There were no significant injuries (N=0) in any of the fencing bouts. Two small bruises (N=2) the size of a 1 euro coin, were noted in the MEF.

Table 2: Injuries

Injury type	MEF	FEF
Severe injury	0	0
Small injury	0	0
Big bruises	0	0
Medium bruises	0	0
Small bruises	2	0

Independent sample test

The results of the independent sample test are listed in table 3. The used force and power of striking, the mental intensity and concentrations, techniques and tactics proved significand different from zero (0) or had a tendency towards significance.

values larger than zero tend towards FEF, means lower than zero towards MEF. Equal to zero there was no difference between the two fencing settings.

Mental intensity and concentration, techniques and tactics proved more in the MEF whereas the power of striking and trusting proved more forceful in the FEF. Physical intensity and exhaustion were not significantly different.

Table 3: Independent t-test.

Variable	Mean	Std. Deviation	P value	Sig
Power of strikes and thrusts	1,57	1,478	<0,001	*
Physical intensity	0,21	2,226	0,621	NS
Mental intensity and concentration	-1,57	1,675	<0,001	*
Techniques	-1,57	2,012	<0,001	*
Tactics	-1,43	1,977	<0,001	*

<0 favours MEF; =0: neutral; >0: favours FEF; * Significant ; ** Tendency towards significance; Ns: not significant

Paired test:

Where necessary parametrical or non-parametrical test were conducted for the following variables: fencing variables (1). The data is listed in table 4. All but one (perceived tactical skill, in the peer score) proved significant or a tendency towards significance.

Table 4: Paired sample t-test

Pair	Variable	Mean	Std. Dev	Difference between means	P value	S
Pair 1	*Force A MEF*	4,87	1,383	-1.20	<0.001	*
	Force A FEF	6,07	1,143			
Pair 2	*Force B MEF*	4,87	1,306	-0.90	<0.001	*
	Force B FEF	5,77	1,406			
Pair 3	*Exhaustion A MEF*	5,83	1,821	-0,667	0,055	**
	Exhaustion A FEF	6,50	1,570			
Pair 4	*Exhaustion B MEF*	5,50	1,697	-0,700	0,022	*
	Exhaustion B FEF	6,20	1,375			
Pair 5	*Mental Intensity A MEF*	7,43	1,524	0,767	0,017	*
	Mental Intensity A FEF	6,67	1,539			
Pair 6	*Techniques A MEF*	6,37	1,671	1,400	<0,001	*
	Techniques A FEF	4,97	1,629			
Pair 7	*Techniques B MEF*	6,27	1,929	0,633	0,062	**
	Techniques B FEF	5,63	1,608			
Pair 8	*Tactics A MEF*	6,03	1,829	0,733	0,015	*
	Tactics A FEF	5,30	1,725			
Pair 9	*Tactics B MEF*	6,07	1,799	0,367	0,228	NS
	Tactics B FEF	5,70	1,784			

MEF: Medium Equipment Fencing; FEF: Full Equipment Fencing; A: Fencers own score; B: Score attributed to the fencing of the opponent (peer score) ; * Significant; ** Tendency towards significance; Ns: not significant

Discussion

Prevention is the first line of defence in the decrease of the severity and the total amount of injuries. It has been around since ancient Greece (González-Gross & Melendez,2013; Kleisiaris,2014). Prevention can be quite challenging since there are many contributing factors (Finch,2006; Vantiggelen,2008; Windt & Gabbet, 2014). Van Tiggelen et al published a model for the development of protective equipment and preventive measures in 2008. It is based, but more elaborate than the 1992 model of Van Mechelen.

The first important step is to find the *aetiology* of the injury of the problem. Second it is important to know the *epidemiology*. Then preventive measures can be made. These

preventive measures have to fulfil several factors. First these measures have to have a certain *efficacy*. Is the preventive measure protecting what it is supposed to protect. For example. Head gear protects against blows on the head and head injuries of fighter A but boxing gloves worn by fighter B do not protect fighter A sufficient against impact forces (Fife etal.,2012; McIntosh, 2015, Osullivan,2005). Yet, when head gear and descend hand protection in striking arts are combined, they generate a better efficacy of the head gear (McIntosh, 2015) This means that protective measures have to be well thought through. Secondly it has to be *efficient* (easy to ware). If the preventive measure is not easy to wear, it will not be used. Then there is the *compliance* and *economics*. Are the athletes/fencers actually applying the protective measure. Finally there is, *Risk compensation behaviour*. When the preventive measure or protective equipment is worn, does it might result in risk compensation behaviour (Finch, 2006; Vantiggelen et al,2008; Windt & Gabbet, 2014).

Risk compensation behaviours are more risk full behaviours that an athlete/fencer shows due to the fact that he/she is wearing protective equipment and that the fencer feels safer for him/herself or his/her adversary. Risk compensation behaviours are known for there negative impact on preventive measures and equipment and dan diminish its effects or even nullify it (Finch, 2006; Van tiggelen et al, 2008). Head gear for instance do protect against blows, yet when fighters kick hard enough, the impact forces can still be very large (Fife et al.2012; McIntosh, 2005, McIntosh et al, 2015 Osullivan,2005; Gupta, 2011)

The aim of this study was to investigate whether RCB might present in Historical European Martial Arts. 2 settings of fencing were conducted with equal values, one with minimal protective equipment (MEF) and one with full (tournament) equipment fencing (FEF). Since the settings and the rulesets were exactly the same, differences in force and intensity might be related to RCB. All variables that involved intensity and force of the fight were significantly higher in the FEF than MEF. So it is clear that, wearing more equipment results in more forceful fights, according to these results. In both settings only the head was targeted, and no changes in protective equipment was made on that level. Yet when fencers wore more protective equipment, they tend to fence more forcefully, even though the more protected areas were no target.

Force of fighting, blows and thrusts were higher in the FEF than in the MEF (Paired sample tests: 1.2 and 0.9 on a 10 point scale; $p<0.001$). Perceived physical intensity was also altered. The paired testing suggested small differences (0.667 on a 10 point scale; $p=0.055$, 0.700 on a 10 point scale; $p=0.002$) favouring FEF. The non significance in the second questionnaire might be due to the fact that sometimes raisings in mental intensity also raises physical intensity due to stress and tight and flight reaction. Another explanation can be that the question in the second questionnaire was not formulated well.

Mental intensity and concentration as well as own rated, technique performance and tactical performance were significantly higher in the MEF than the FEF. The independent test showed significant differences favouring MEF for mental intensity, technical and tactical performance. Since the fights were fought more forcefully and intense in FEF than in MEF focus of the

fencer might be put more on defensive actions and swift parades and reposts rather than technical and tactical implications. Since there is less force in MEF there might be more "time" during the fencing and offensive actions to react with a proper technical and tactical counterreaction. This data suggests that, due to RCB, technical and tactical applications are less in FEF than in MEF.

To date there are no comparable studies conducted in HEMA. The authors could not find other studies in martial arts that compared the presence of protective equipment in full combat regarding risk compensation behaviour, so there is no data to compare with.

These data concern us in a few ways: Firstly, minimal protection of course is necessary. Head gear in general is excellent in reducing head impact (mcIntosh, 2015; Fife et al. 2012; Gupta, 2011) and removal of head protection in competition in other martial arts has proven to increase the amount of injuries (Lystad et al. 2021). But head impact forces (HIF) can still be great in some forceful blows, even when wearing head protective equipment causing concussions (McIntosh,2015; O'sullivan, 2005; Fife et al. 2012; Gupta, 2011). Therefore, an increase in HIF due to RCB can lead to a secondary problem of mild concussions that have been reported in HEMA (Wauters,2016). These concussions are associated with mild (repetitive) brain injuries. Concussions still can occur when wearing proper head protection (Musumeci, 2019). Mild repetitive brain injuries should not be underestimated since they can lead to serious problems such as neural and axial brain damage with associated problems such as memory, concentration and cognition deficits and even dementia (Fehili & Fitzgerald; 2017; Martinez-Perez et al, 2017) If RCB makes fencers fence more powerful, and the power exceeds the helmets capacity to absorb the impact, problems may occur. More research on the field of head gear in Hema is required.
Secondly, when RCB makes fencers fence more powerful, and the power exceeds the protective equipment's capacity to absorb the impact, problems may occur. People can have the perception that equipment is not sufficient, and extra protective equipment is added, giving more RBC et cet. It is known in other martial arts that increased intensity gives an increase of injuries in general. (Critchley et al, 2008; Lystad etal, 2015; Wauters & Van tiggelen, 2016 Ziaee et al, 2015;).

Risk compensation has to be considered within each setting. Wearing a safety helmet might give some negative connotation in terms of risk compensation behaviour, but the benefits of the prevention of injuries outweigh the risk compensation behaviour (in most cases).

Limitations

This study has, as any other study, some limitations. Limiting the head as a target can have tactical implications if one is not used to fence this way. Secondly, HEMA is a small, yet rapid developing martial art. A lot of high ranked and top-class fencers know each other personally and consider each other friends. Several of the fencers also knew each other and consider each other friends. Therefore, some fights were in an amical sphere. They did not intent do hurt one another. This might suggest why some differences are significant yet small in scale and absolute number. One can assume that in tournament, where the amicability is

less, fencers less mind hurting the opponent with harder blows.
The questioning about fencing force was done by questioning which makes the data subjective. It would be interesting to investigate this principle with objective data by sensory force measurement.

Conclusion

This data proved that RCB is present in HEMA. Tournament organisations and manufacturers of protective equipment should be aware of this principle. Of course, it would be utterly wrong to state that is safer to fence without any protection in full contact tournament settings. The more intense the fight the more need there is for protective equipment. Yet the opposite also applies. Fencers, coaches, trainers, organisations of tournaments and producents of protective equipment have to be aware of the dangers that might lure in wearing more protective equipment. This might enhance fighting intensities in free fencing, sparring and tournament settings with more forceful fencing and higher (head) impact forces. Technical and tactical aspects are considered grater in a fencing situation with less protective equipment. Technical tournaments with technical scoring can be held this way.

Competing interests

There are no competing interests of any kind in the development of this research and paper.

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The pictures were taken at official Netherland and Belgian tournaments and by tournament organizations. The people in the picture gave their consent to these organization to be photographed, and organizations gave their consent to use the photos. Faces were blurred for privacy reasons.

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Tables

Figures