ROTATION SCHEMES OF THE BEST FEMALE GYMNASTS IN THE WORLD

Flavio Bessi and Jan Pfeifer

Albert-Ludwigs-University of Freiburg, Department for Sport and Sport Science, Germany

Original article

Abstract

Worldwide trainers ask if there is a rotation scheme, which improves the gymnastics performance and/or facilitates the learning of the elements with longitudinal rotations. Although there are some surveys and scientific publications on it, we still are seeking for more data to understand the undergoing relationships within the rotation habits of high-level gymnasts. In a recent study, the Men's Individual All□Around finalists at the Olympic Games Rio 2016 were categorized using the current classification system of rotational schemes. This study aims first to categorize the Women's Individual All□Around finalists at the Olympic Games Rio 2016. Furthermore; the analysis should help to improve the classification system by comparing both genders. We assume that the female rotation scheme should be more complicated due to the requirements of choreographic movements and gymnastic turns. In this context, the study aims to set a viable classification system for female gymnasts as well. The study revealed that 52% of the female finalists turn to the right while 48% prefer to rotate to the left after having crossed out the dance and gymnastic elements.

Key words: *laterality, rotational preference, rotation scheme, lateral consistency.*

INTRODUCTION

After many years of opinions and speculations about possible turning systems, in recent publications the recording of rotating schemes of gymnasts was systematized (Bessi, Hofmann, Laßberg, & Heinen, 2016; Schindler, 2016; Bessi, 2018; Pfeifer, 2018). This study aims first to analyze the Women's Individual All-Around finalists at the Olympic Games Rio 2016 regarding the preferred turning scheme analog the analysis of the Men's Individual All-Around finalists at the Olympic Games Rio 2016 (Bessi, 2018). Since the women are analyzed for the first time using the categorization matrix, we are looking for peculiarities that have to be considered to better understand the undergoing relationships of the turning habits of high-level gymnasts. We assume that the female rotation scheme should be more complex due to the requirements of choreographic movements and gymnastic turns. In this context, the study aims to set a viable classification system for female gymnasts as well.

To avoid misunderstanding, we want to start with some definitions.

Direction of Rotation: Defined from the perspective of the gymnast, a rotation to the left in upright stance corresponds to a backward rotation of the left shoulder and forward rotation of the right shoulder. When observing from above, the gymnast performs a counterclockwise rotation. A rotation to the right in upright stance is defined vice versa, i.e., a clockwise rotation when observing from above (see Figure 1).

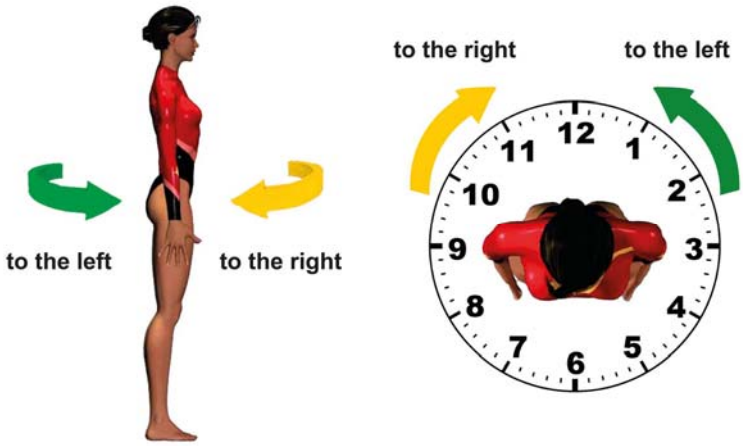

Figure 1. Definition of the rotation direction around the longitudinal axis.

Round-off designation: Since we used the round-off as an essential element to determine the turning system, it is crucial to understand that the designation of the round-off direction is the opposite to the rotating direction of the body. When performing a left round-off (i.e., putting the left-hand first on the floor, as shown in Figure 2) the gymnast rotates indeed to the right with her body around the longitudinal axis.

Figure 2. A round-off left is indeed a rotation to the right around the longitudinal axis.

Upright and upside down: Many publications and unpublished recordings have confirmed that there is a strong bias among gymnasts to rotate in upright stance in the opposite direction as upside down (Bessi, 2006, 2018; Coren, 1993; Heinen, Jeraj, Vinken, Velentzas, & Vinken, 2012; Sands, 2000; Schweizer, 2008; Wüstemann & Milbradt, 2008). Therefore, the determination of the state is fundamental before determining the direction of turn. However, until now the exact definition of

these two states „upright" and "upside down" is not set. Some Authors just divided the sagittal plane into two halves (Faber, 2018; Koscielny, 2009; Schindler, 2016). Rotations below the horizontal line on the sagittal plane are considered by them in upright stance and above the horizontal line as upside down. There is some evidence (and above all, the subjective feeling of many surveyed gymnasts) that the change in spatial orientation occurs later when the body is more vertical. Therefore, we want to introduce a practicable demarcation between the positions, which take into account this phenomenon. We propose to use a system that considers the position in the phase of initialization of the rotation about the longitudinal axis (Figure 3). All elements starting the rotation around the longitudinal axis in the green area are considered in upright stance even if the body is horizontal or slightly above the horizontal plane (for example like the right gymnast in the figure triggering the rotation to the right). All elements, which start a longitudinal rotation in the white area, are considered upside down.

Type of elements: We used as differentiation the terms "dance", "gymnastic" and "acro". *Dance* elements are all elements that are not included in the Code of points and that serve the choreographic design of the routines. *Gymnastic* elements are the leaps, jumps, hops, and turns. In this study *Acro* are all other elements, even if they could not be acrobatic elements in the real sense like a giant circle backward with 1/1 turn (360°) to handstand.

Figure 3. Definition of the state upright or upside down.

METHODS

Participants

The 24 finalists of the Women's Individual All-Around during the Olympic Games Rio 2016 (Organizing Committee, 2016) were examined with regard to their directions of rotation. The routines were analyzed using the videos of IRCOS® (Instant Replay & Information System).

We analyzed all routines of the finalists who finished the whole competition. The distribution of the analysed nations was as follow: USA (2), RUS (2), CHN (2), CAN (2), VEN (1), JAP (2), NED (2), SUI (1), BRA (1), ITA (2), GBR (1), FRA (2), GER (2), BEL (1). Unfortunately, the Brazilian

Jade Barbosa suffered an injury during the competition and could not finish it. So she was removed from the sample.

Instruments and procedures

The elements with rotation around the longitudinal axis of the 23 gymnasts, the direction of turning and the state upright or upside down according to the definition above were registered. In addition, we recorded for the first time the type of movement with the categories dance, gymnastic or acro according to the definition set above (Table 1). The reason is that previous research included only male gymnasts. Women artistic gymnastics has other requirements set by the Code of Points (Fédération Internationale de Gymnastique, 2016). Altogether, the gymnasts made a total of 686 elements with longitudinal rotations during the competition. We registered 361 acrobatic elements (207 to the left and 154 to the right); 79 gymnastic elements (35 to the left and 44 to the right) and 246 dance elements (142 to the left and 104 to the right) and as shown in Table 2 (Fédération Internationale de Gymnastique, 2012).

With these data, we determined which rotational scheme the gymnasts follow using a slightly modified classification system.

Basically, we use the classification system proposed in Bessi (2018), which has two basic pure categories: bilateral and unilateral consistent accompanied by the direction of turn, left or right (Figure 4). Nevertheless, we altered a detail regarding the number of elements that do not fit into the scheme. We propose from now the use of percentage numbers instead of absolute numbers to take into account that different gymnasts can perform different amounts of elements with rotation around the longitudinal axis. We found large differences in the amount of turning elements. For example, Louise Vanhille (FRA) showed 10 acrobatic elements with rotations around the longitudinal axis while Shang Chunsong (CHI) performed 21 elements.

Bilateral consistent rotation scheme (BC): A pure bilateral consistent rotating gymnast always rotates in the opposite direction around the longitudinal axis when being in an upside down position, as compared to when being in an upright position. The best way to identify the type of rotation scheme is to start observing the round-off and the back somersault with turn. Such a gymnast performs the round-off left (i.e., rotating right, as shown in Figure 2), and the twist to the left.

Unilateral rotation scheme (U): A pure unilateral rotating gymnast always rotates in the same direction, independent of the element or the body orientation in space. Such a gymnast performs, for example, the round-off left (i.e., rotating right, as shown in Figure 2), and a somersault backward with turn to the right as well.

Certainly, some considerations may lead to the decision that a gymnast has (or wants) to give up the preferred rotation scheme partly depending on the situation. For example, performing an acro line on floor a gymnast could change the direction of a salto forward with twist after a salto backward stretched with 1½ twist to take advantage of the ground reaction force produced by the antecedent movement. To consider these eventualities, we counted elements that do not fit into the scheme up to a maximum of 20% of all turning elements during the whole all-around. In this case, we weaken the pure basic rotational type by identifying it with the word *restricted*.

Restricted bilateral consistent rotation scheme (BCr): A restricted bilateral consistent rotating gymnast is basically a BC gymnast. However, she shows up to a maximum of 20% of all turning elements during the All-Around competition that do not fit the pure BC scheme.

Restricted unilateral rotation scheme (Ur): A restricted unilateral rotating gymnast is basically a U gymnast. However, she shows up to a maximum of 20% of all turning elements during the All-Around competition that do not fit the pure U scheme.

Table 1

Example of the registration. Here the records of Simone Biles (USA) on Floor.

Video position	Element [# in Code de Pointage]	Turning direction	Position	Type
00:26	Turn in Stand	left	upright	Dance
00:28	Turn in Stand	left	upright	Dance
00:31	Round-off [3.106]	left	upside down	Acro
00:32	Double salto backward stretched with 1/1 twist (360°) [5.803]	left	upside down	Acro
00:38	Turn in Stand	right	upright	Dance
00:41	Side split jump with 1/1 turn [1.307]	right	upright	Gym
00:44	Turn in Stand	right	upright	Dance
00:47	Round-off [3.106]	left	upside down	Acro
00:48	Double salto backward stretched with ½ twist [5.703]	left	upright	Acro
00:56	Turn in Stand	left	upright	Dance
00:59	Turn on floor	right	upright	Dance
00:59	2/1 turn in tuck stand one leg (double wolf turn) [2.407]	right	upright	Gym
01:01	Turn in Stand	right	upright	Dance
01:04	Turn on floor	right	upright	Dance
01:11	Split leap with 1 ½ turn [1.401]	left	upright	Gym
01:13	Turn in Stand	left	upright	Dance
01:19	Round-off [3.106]	left	upside down	Acro
01:20	Double salto backward tucked with 2/1 twist [5.802]	left	upright	Acro
01:27	Turn in Stand	left	upright	Dance
01:34	Switch leap with 1/1 turn in flight phase [1.404]	right	upright	Gym
01:43	Round-off [3.106]	left	upside down	Acro
01:44	Double salto backward tucked with 1/1 twist [5.502]	left	upright	Acro
01:48	Round-off with ½ turn	left	upside down	Acro
01:50	Turn on floor	right	upright	Dance

Table 2

Frequencies of turning elements in the different categories.

		Rotation		
		left	right	Total
Acro	upright	112	83	
	upside down	95	71	
	Total acro	207	154	361
Gymnastic		35	44	79
Dance		142	104	246

The terminology of pure and restricted rotation schemes should be preceded by the direction of turning in upright stance. Former analyses indicate that it is best to determine this by the direction of the backward twist. Therefore, the classification system has eight theoretically possible categories: left bilateral consistent (lBC), left bilateral consistent restricted (lBCr), left unilateral (lU), left unilateral restricted (lUr), right bilateral consistent (rBC), right bilateral consistent restricted (rBCr), right unilateral (rU) and right unilateral restricted (rUr) (see Figure 4). However, this is only theoretical as we will show in the next pages.

All gymnasts, who do not fit into the preceding categories, are labeled with *no distinguishable rotation scheme* (ND). At this point, it seems appropriate to mention that "no distinguishable rotation scheme" is not an evaluative category. It only indicates that the conditions of the four aforementioned categories (BC, BCr, U, Ur) are not fulfilled during the analysis of the corresponding elements of the given gymnasts.

That means that a gymnast, who turns according to a rotational scheme but has up to 20% of the turning elements in the opposite to the expected direction, is assigned to the corresponding category preceded by the weakening *restricted,* while another gymnast doing so but with more than 20% of unexpected elements passes to the category *no distinguishable rotation scheme*. Even if this limit is based on our experience while analyzing a large number of gymnasts the definition is arbitrary and serves exclusively for differentiation.

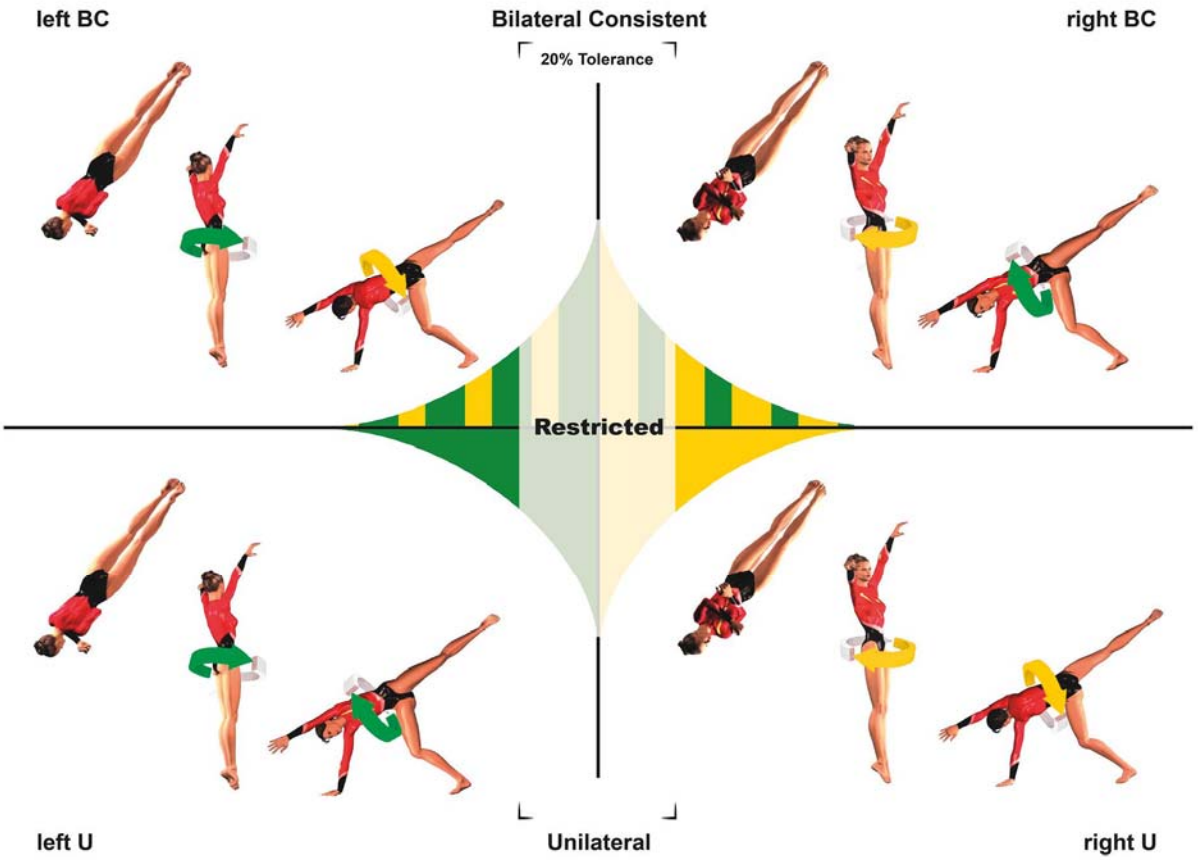

Figure 4. Classification matrix of turning schemes.

RESULTS

After having analyzed all elements, we decided to discard the dance and gymnastic elements since the consideration of them led to a result where no gymnast presented a distinguishable rotation scheme. At the end, only acrobatic elements were taken into account. With this change, all gymnasts of our sample were classifiable.

In former studies it was determined that the majority of the gymnasts exhibit a leftward turning preference. Until now the results were only obtained on the basis of the analysis of male gymnasts. We could not verify this with our selected sample of female gymnasts. The results revealed that 52% of them turn to the right while 48% prefer to rotate to the left after having crossed out the dance and gymnastic elements.

18 of all finalists have a pure bilateral consistent turning scheme (78%). Thus this seems to be the "normal" scheme of rotation. Ten gymnasts turn to the right and eight to the left. Only four gymnasts have a restricted turning scheme (two turn to the right and two to the left). Particularly striking is the category of unilateral rotation scheme, which was opened by the first placed Simone Biles (see Figure 5). So far no world class (male) gymnasts belong to this category. No lUr, rU or rUr gymnasts were among the finalists.

The rotational scheme seems not to influence the performance to determine who takes the medals. The distribution of the detected schemes is quiet even (see Table 3).

Table 3
Results of the Women's Individual All-Around Final at the Olympic Games in Rio 2016 and their rotational schemes.

Place	Gymnast	Country	Rotational Type
1	BILES Simone	USA	lU
2	RAISMAN Alexandra	USA	rBCr
3	MUSTAFINA Aliya	RUS	lBC
4	SHANG Chunsong	CHN	lBCr
5	BLACK Elsabeth	CAN	lBC
6	WANG Yan	CHN	lBC
7	LOPEZ Arocha JB	VEN	rBC
8	TERAMOTO Asuka	JPN	lBC
9	THORSDOTTIR Eythora	NED	rBC
10	STEINGRUBER Giulia	SUI	rBC
11	ANDRADE Rebeca	BRA	rBC
12	FERLITO Carlotta	ITA	rBC
13	DOWNIE Elissa	GBR	lBC
14	MURAKAMI Mai	JPN	rBC
15	BREVET Marine	FRA	rBC
16	FERRARI Vanessa	ITA	lBCr
17	SEITZ Elisabeth	GER	lBC
18	ONYSHKO Isabela	CAN	rBCr
19	DERWAEL Nina	BEL	rBC
20	WEVERS Lieke	NED	rBC
21	VANHILLE Louise	FRA	lBC
22	TUTKHALIAN Seda	RUS	lBC
23	SCHEDER Sophie	GER	rBC

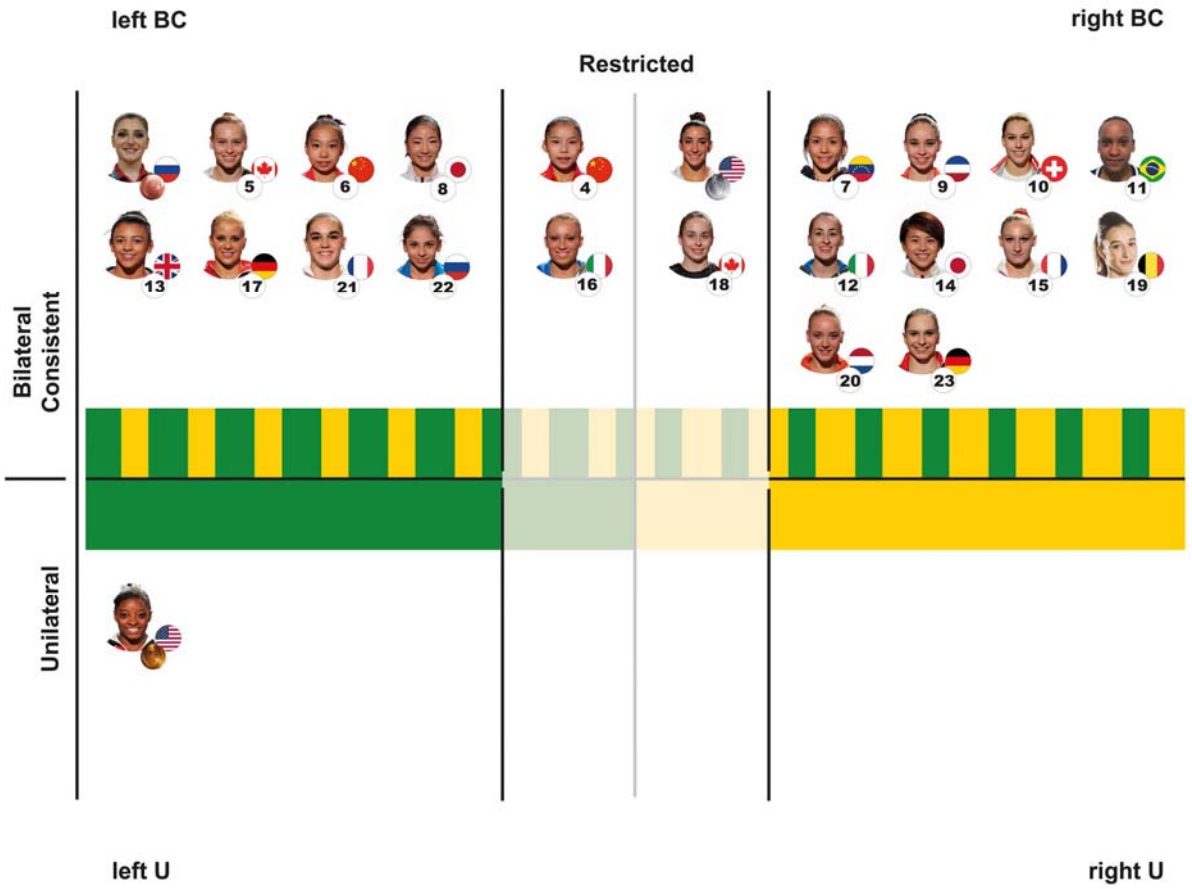

Figure 5. The gymnasts of the Women's Individual All-Around at the Olympic Games 2016 with their respective rankings sorted by their rotational scheme.

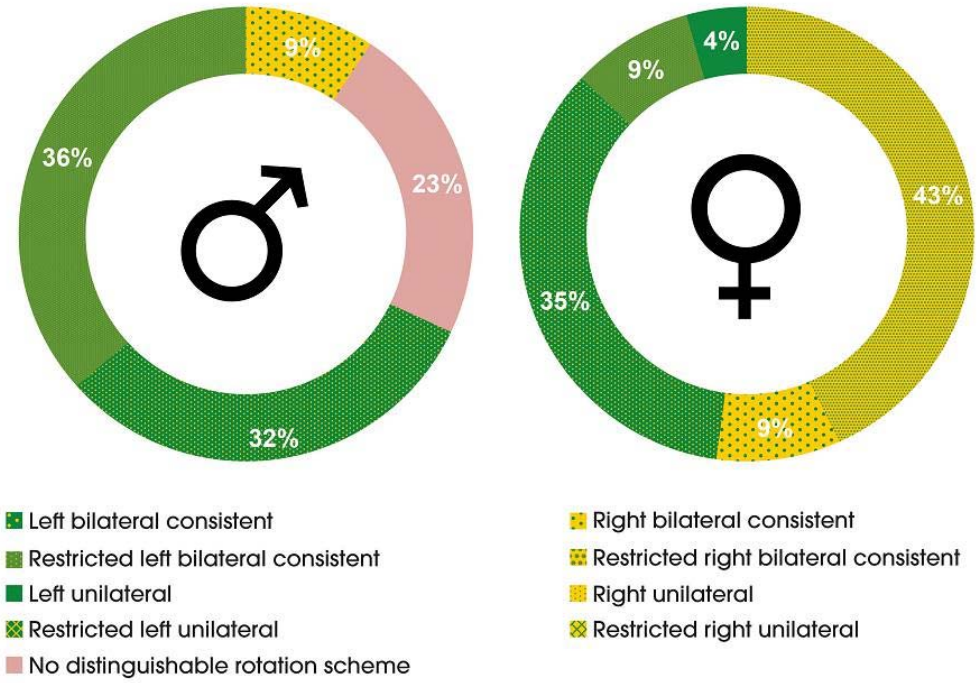

Figure 6. Comparison of the rotational schemes of the male and female gymnasts of the Individual All-Around Finals at the Olympic Games 2016 (only acrobatic elements).

There were nine countries that were able to qualify two gymnasts to the final (USA, RUS, CHN, CAN, JAP, NED, ITA, FRA, and GER)[1]. Only two nations (RUS and NED) seem to have a preferred rotational scheme. Both Russian gymnasts are lBC while the two Dutch gymnasts are rBC. With the current data and without having interviewed the national responsible person we cannot say if this finding is casual or a desired development in the sense of a national strategy. It would be interesting to know, whether the scheme was explicitly targeted or not to see if there is a national strategy inducing this result.

DISCUSSION

The current classification system can be used both for female and male gymnasts. However, until now the classification is only able to consider acrobatic elements. For a better understanding of the relationship between the elements with rotation around the longitudinal axis more data is needed. Above all, the relationship between dance, gym, and acrobatic elements is not yet clear and require further analysis. Therefore, we consider that the rotation scheme of world-class gymnasts should be further analyzed and recorded in a comprehensive database. It should be thought about the possibility to take into account further aspects like earedness and eyedness to determine which is the "right" turn direction.

The distribution of left and right turning female gymnasts was surprising at first. However, we believe that this distribution could be explained by the fact that female gymnasts experience a continuous ballet training which traditional contains turns to the right (Golomer, Rosey, Dizac, Mertz, & Fagard, 2009).

Female gymnasts seem to have a more systematic instruction than their male counterparts. This is only speculation. We do not have any evidence or reference sustaining this assumption. Despite that, we still believe that there is a big potential for improvement if the turning elements are taught more systematically. Additional review of the last codes of points reveals that the amount of turn elements is steady increasing in the last decades. The difficulty is decisively influenced by the numbers of turns. Therefore, we consider that the treatment of laterality issues must be forced in coaches‘ education. We are aware that a performance-facilitating rotational scheme is not necessarily needed when the level to be achieved is not very high. For instance, it is not a big problem for a performer in a context of Gymnastics for All to rotate the forward twist to the right and the backward twist to the left if they are the highest level skills that he will ever perform. This kind of lack of consistency occurs typically at a low level because neither the gymnast nor his coach perceives that the chosen direction for the forward twist corresponds to the direction of the round-off, which is indeed the opposite direction as explained above. However, at the least when the goal is to achieve excellence, coaches have to be sensitized to the fact that a logical rotation scheme is a crucial aspect that should be given attention from the beginning. Given that human beings decide at a very young age which is the preferred side to rotate, coaches have to pay attention and to influence the development of the skills actively. The gymnast performing twists forward and backward in different directions may have big troubles when trying to learn complex skills such as a Kasamatsu on floor, especially when using the technique half-in, half-out because in this case, the gymnast will twist during both a backward and a forward salto.

In this study, we replaced the absolute number of two non-matching elements through a percentage of 20 of all performed turning elements. In this context, it could be better to consider elements with the same number in the code of points only once. Otherwise, the possibility to disregard the scheme grows disproportionately (for

[1] Brazil qualified also two gymnasts, but one could not be analyzed because she could not finish the competition.

instance considering 3-4 round-offs in a routine).

A last aspect that has to be considered in the context of lateralization in further research, is the associated physiologically trained asymmetry. Bučar Pajek, Hedbávný, Kalichová, and Čuk (2016) found out that gymnasts do not have a balanced use of both legs during their balance beam routines, but a predominant use of the right leg. According to Niu, Wang, He, Fan, and Zhao (2011) a specific rotational training may lead to an increasing injury risk if no measures are planned in training to counteract the asymmetry.

CONCLUSIONS

Finally, we want to give some recommendations for the daily training.

- Recognize very early the natural direction of rotation of the athletes. This may be already set when you take charge of them. To identify this, exercises such as the following can be used:
  - Straight jump with ½ turn
  - Reaction tasks (the best is a competition), which also contain the need of rotation (i.e., standing, sitting or lying on the floor run to the coach when he claps his hands and tap him.
- Do not try to alter the natural direction of rotation.
- Teach the subsequent or following skills in concordance with the rotational scheme you consider the best. In our opinion you should teach BC schemes, left or right depending on the natural predisposition. The most important indicator to identify the appropriated turn direction is the support leg by swinging to handstand or performing a round-off. If a gymnast uses the left leg as the support leg during the round-off (as shown in Figure 2), he should turn to the left and vice-versa in order to be a bilateral consistent turning gymnast.
- In some cases, if the rotational scheme is not correct and the gymnast is still young consider changing the movements which do not fit into the scheme.
- If in some cases, you ignore the chosen scheme of rotation, be aware why you are doing so.

REFERENCES

Bessi, F. (2006). *Trainingsprotokolle der Jahrgänge 1989, 1990, 1991* [Training records of gymnasts from the age groups 1989, 1990, 1991]. Herbolzheim.

Bessi, F. (2018). Rotations and twisting in gymnastics, is there a universal rotational scheme? In M. Jemni (Ed.), *The science of gymnastics: Advanced Concepts* (2nd ed., pp. 255–265). London, New York: Routledge, Taylor & Francis.

Bessi, F., Hofmann, D., Laßberg, C. v., & Heinen, T. (2016). Directional Tendencies in Artistic Gymnastics. In T. Heinen (Ed.), *Sports and Athletics Preparation, Performance, and Psychology. Gymnastics Performance and Motor Learning* (pp. 119–138). Hauppauge: Nova Science Publishers Inc.

Bučar Pajek, M., Hedbávný, P., Kalichová, M., & Čuk, I. (2016). The asymmetry of lower limb load in balance beam routines. *Science of Gymnastics Journal*, *8*(1), 5–13.

Coren, S. (1993). The lateral preference inventory for measurement of handedness, footedness, eyedness, and earedness: Norms for your adults. *Bulletin of the Psychonomic Society*, *31(1)*, 1–3.

Faber, L. (2018). Analyse ausgewählter Turnerinnen bei der Weltmeisterschaft in Nanning 2014 hinsichtlich des Drehschemas (Zulassungsarbeit). Albert-Ludwigs-Universität Freiburg, Freiburg.

Fédération Internationale de Gymnastique. (2012). *2013 Code of points. Women's artistic gymnastics: Version August 7th, 2012*. Lausanne.

Fédération Internationale de Gymnastique. (2016). *2017 Code of points. Women's artistic gymnastics*. Lausanne.

Golomer, E., Rosey, F., Dizac, H., Mertz, C., & Fagard, J. (2009). The influence of classical dance training on preferred supporting leg and whole body turning bias. *Laterality*, *14*(2), 165–177. https://doi.org/10.1080/13576500802334934

Heinen, T., Jeraj, D., Vinken, P. M., Velentzas, K., & Vinken, P. M. (2012). Rotational preference in gymnastics. *Journal of Human Kinetics*, *33*, 33–43. https://doi.org/10.2478/v10078-012-0042-4

Koscielny, B. (2009). Analyse der Mehrkampffinalistinnen und Mehrkampffinalisten bei der FIG Turn WM 2007 hinsichtlich eines Drehschemas (Zulassungsarbeit). Albert-Ludwigs-Universität Freiburg, Freiburg.

Niu, W., Wang, Y., He, Y., Fan, Y., & Zhao, Q. (2011). Kinematics, kinetics, and electromyogram of ankle during drop landing: a comparison between dominant and non-dominant limb. *Human Movement Science*, *30*(3), 614–623. https://doi.org/10.1016/j.humov.2010.10.010

Organizing Committee. (2016). *Results Book: Gymnastic Artistic 6-16 August*. Rio.

Pfeifer, J. (2018). Analyse der Mehrkampffinalistinnen im Turnen der Olympischen Spiele 2016 in Rio hinsichtlich des Drehschemas (Bachelorarbeit). Albert-Ludwigs-Universität Freiburg, Freiburg.

Sands, W. A. (2000). Twist direction. *Technique*, *2000*. Retrieved from https://usagym.org/pages/home/publications/technique/2000/2/twistdirection.pdf

Schindler, S. (2016). *Analyse der Mehrkampffinalisten bei der FIG Turn WM 2014 in Nanning hinsichtlich eines Drehschemas (Zulassungsarbeit)*. Albert-Ludwigs-Universität Freiburg, Freiburg.

Schweizer, L. (2008). *Biomechanische Grundlagen von Schraubenbewegungen beim Bodenturnen: Vortrag während der Freiburger Gerätturntage*, Freiburg.

Wüstemann, S., & Milbradt, J. (2008). *Seitigkeit von Längsachsendrehungen*. Vorstellung beim Kadertrainerseminar. Berlin.

Corresponding author:

Flavio Bessi
Albert-Ludwigs-University of Freiburg
Department of Sport and Sport Science
Schwarzwaldstr. 175
79117 Freiburg
Germany
Phone: +49 761 2034525
e-mail: fb@sport.uni-freiburg.de