ROTATION SCHEMES OF THE BEST FEMALE GYMNASTS IN THE WORLD

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Flavio Bessi and Jan Pfeifer analyzed the twisting patterns of the Women's Individual All-Around finalists in the Olympic Games, Rio 2016. Their original article is very well done and fascinating. I have tried to summarize the more esoteric parts of less interest to coaches and discuss the original, pertinent information. Coaches who would like to look deeper into this subject should read their original article in the on-line Science of Gymnastics Journal. Moreover, their research raises several interesting and important questions.

Bessi and Pfeifer recorded the rotation directions of the 24 finalists of the Women's Individual All-Around during the Olympic Games Rio 2016. During the competition, one finalist was unfortunately injured and could not finish, so their raw data was from 23 gymnasts. First, Bessi and Pfeifer defined **"Direction of Rotation**", **"Round-off Designation"**, and **"Upright and Upside Down"** in order to classify rotation direction of the body. These definitions have an important influence on the results they found. These definitions themselves are an important difference between their analysis and previous work on twist direction.

Direction of Rotation: This establishes what is "right" and what is "left". From the perspective of the gymnast in upright stance, a twist to the left 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 an upright stance is defined vice versa, i.e., a clockwise rotation when observed from above. (See Fig. 1 from Bessi & Pfeifer, 2018).

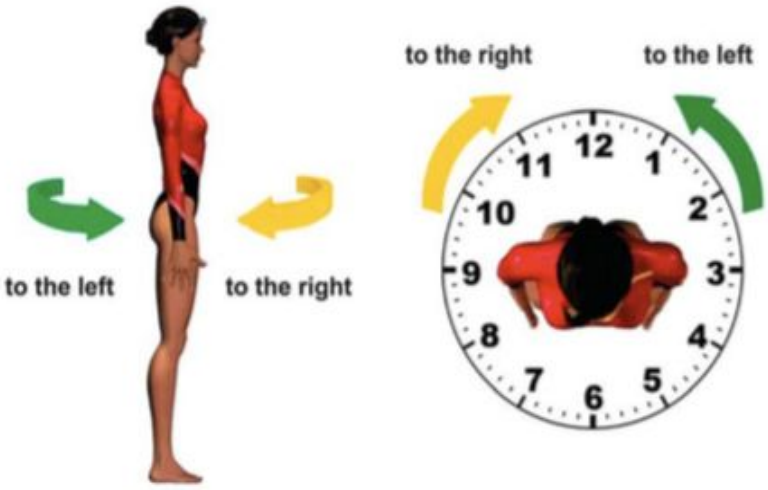

Figure 1. Definition of the rotation direction around the longitudinal axis.

Round-off Designation: Bessi and Pfeifer identified the round-off as a skill essential in identifying a gymnast's twisting system. Round-offs are performed in the floor exercise, vault, and balance beam. Therefore, it is important to understand that the designation of the round-off direction is the opposite to the rotating direction of the body. When putting the left hand down on the floor first to perform a left round-off, the gymnast rotates to the right with her body around the longitudinal axis. Correspondingly, when putting the right hand down on the floor first for a right round-off, the gymnast rotates to her left. (See Fig. 2 from Bessi & Pfeifer, 2018).

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

Upright and Upside Down: Bessi and Pfeifer (2018) write that, “Much research has confirmed that there is a strong bias among gymnasts to rotate in upright stance in the opposite direction as upside down. Therefore, the determination of the state is fundamental before determining the direction of turn. However, the exact definition of these two states ‘upright’ and ‘upside down’ is not set. 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 practical demarcation between the positions that takes into account this phenomenon. We use a system that considers the position during initialization of the rotation about the longitudinal axis: all elements starting the rotation around the longitudinal axis with the head above the feet in the horizontal plane are upright, even if the body is horizontal or feet slightly above the horizontal plane. All elements which start a longitudinal rotation with the feet considerably higher than the head in the horizontal plane are considered upside down.” (See Fig. 3 from Bessi & Pfeifer, 2018). Adding a head-up or head-down criteria to the analysis of turn direction is an original and important progress compared to previous research on turn direction.

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

Once the rules for identifying turn direction were established, Bessi and Pfeifer needed to define how different skills would be classified. This is important because the directions of some movements could be a function of choreography or Code of Points requirements for pattern, for example in a floor exercise, instead of a feature of the biomechanics of the skill. To classify the **Type of Element**, Bessi and Pfeifer used the system common in gymnastics coaching and judging: “dance”, “gymnastic”, and “acro”. Dance elements are not listed in the Code of Points and serve the choreographic aspect of the routine. Gymnastic elements are the leaps, jumps, and turns. Acro elements were skills listed in the Code of Points “even if they could not be acrobatic elements in the real sense like a giant circle backward with 1/1 turn (360°) to handstand”. (Bessi & Pfeifer, 2018).

Besi and Pfeifer’s Table 1. is an example of how they collected their data based on their previous definitions of Direction of Rotation, Round-off Designation, Upright and Upside Down, and Type of Element (Bessi & Pfeifer, 2018). They only looked at skills with turns or twists, ignoring choreographic elements.

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

Ignoring the dance and gymnastic elements, their study revealed that about half of the female finalists turn to the right while half prefer to turn to the left. The distribution of the detected patterns is almost even (see Besi and Pfeifer's Table 3.). Therefore, rotation pattern does not seem to influence performance or determine who gets the medals. Twisting right or twisting left is not better than the other. Consequently, twist direction is probably not a performance determining factor.

Beside twisting right or twisting left, there are theoretically many possible combinations of twist and turn directions. But among the top 23 all-around finalists only three basic twisting patterns were observed, BC, BCr, and U:

Bilateral consistent rotation pattern (BC): A pure, consistent, bilateral 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 decisive factor is the orientation of the body in space; head-up or head-down. The best way to identify the type of rotation pattern is to observe the round-off and the back somersault with twist. For example, a BC gymnast performs the round-off left (i.e., rotating right), and then twists to the left.

Restricted bilateral consistent rotation pattern (BCr): A restricted bilateral consistent rotating gymnast is basically a BC gymnast. However, she showed up to a maximum of 20% of all twisting elements during this All-Around competition that did not fit the pure BC pattern. 20% is an arbitrary limit, but one that seems to sensibly differentiate the data.

Unilateral rotation pattern (U): A unilateral rotating gymnast consistently 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), and a somersault backward with twist to the right as well.

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

First of all, they found large differences in the number of turning elements performed. For example, Louise Vanhille (FRA) performed 10 acrobatic elements with rotations around the longitudinal axis while Chunsong Shang (CHN) performed 21 elements. Although this is no proof, coaches certainly note that Shang finished fourth while Vanhille placed third to last.

18 of all 23 finalists had a pure bilateral consistent twisting pattern (78% lBC or rBC). BC is the most common pattern. Ten gymnasts twist to the right (rBC) and eight to the left (lBC). Only four gymnasts have a restricted twisting pattern (two twist to the right (rBCr) and two to the left (lBCr)). **Particularly striking is the category of unilateral rotation pattern of the first placed Simone Biles, left Unilateral (lU), the only U. No lUr, rU or rUr gymnasts were among the finalists. So far, no world class male gymnasts are rU, lU, rUr, or lUr.** (See Table 3. from Bessi & Pfeifer, 2018).

Bessi and Pfeifer believe that there is a big potential for improvement in teaching twisting elements more systematically. The amount of turning elements has been steadily increasing over the last decades in the Code of Points. Difficulty (D-score) is decisively influenced by the numbers of rotations. Therefore, they believe that coaching laterality issues should be emphasized in coaches‘ education. On one hand, a performance-facilitating rotational pattern may not be necessary when the level to be achieved is not very high. For example, it will not be a big problem for a recreational gymnast to rotate the forward twist to the right and the backward twist to the left if these are the highest level skills that she or he will ever perform. Bessi and Pfeifer believe that this kind of lack of consistency typically occurs at a low level of performance because neither gymnast nor coach perceives that the direction chosen for the forward twist corresponds to the direction of the round-off, which is indeed the opposite direction, as explained above. “However, when the goal is to achieve high performance, coaches need to be aware of the fact that a logical rotation pattern is a crucial aspect that should be given attention from the beginning. As human beings decide at a very young age which is the preferred direction to rotate, coaches have to pay attention and to actively influence the development of the skills. A gymnast performing twists forward and backward in different directions could have big problems learning 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.” (Bessi & Pfeifer, 2018).

Just nine different countries qualified gymnasts to the Women’s Individual All-Around Finals of the 2016 Olympic Games: USA, RUS, CHN, CAN, JAP, NED, ITA, FRA, and GER. This was in spite of rules limiting each nation to a maximum of two qualifiers. So the nine qualifiers also represent an elite of the best teams in the world. Only two nations (RUS and NED) seem to have a preferred rotational pattern. Both

Russian gymnasts are lBC while the two Dutch gymnasts are rBC. Bessi and Pfeifer were unable to say if this finding is a desired development. It would be interesting to know whether a pattern was explicitly taught, and to know if there is a national strategy making this result because Russia and the Netherlands have very strong teams with some exceptional gymnasts, but founded on very small pyramids of talent.

Bessi and Pfeifer write that, “The rotational pattern seems not to influence the performance to determine who takes the medals.” I disagree with this conclusion. Their results do show that rotating right or left probably does not influence performance. Moreover, the restricted BC also does not seem to affect performance as one BCr placed only 18th, but two other BCr were second and fourth (Raisman and Shang). However, their research raises a number of other interesting questions.

Bessi and Pfeifer (2018) do not comment on the fact that their data shows that no restricted bilateral consistent rotating (BCr) gymnasts with over 20% were able to qualify for finals, even with the maximum-two-gymnasts-per-nation rule. Remember that a BCr gymnast is basically a BC gymnast but performing up to a maximum of 20% of all twisting elements that did not fit the BC pattern. We might guess that performing more than 20% of all twisting elements not fitting a BC pattern is a performance determining factor in the sense that this pattern limits good performance. Too much variety of twist and turn direction by the same gymnast in different skills may be bad. Does this tell us something about how we should be teaching twists and turns?

Most neuro-physiologists agree that the human right or left handed phenomenon is a specialization of the body for higher functionality. We do not know if twisting right or left, for example rounding-off left but twisting left, is also a specialization of the body for higher functionality. We don’t even really know if the twist direction of a gymnast is innate, taught, or some combination. Bessi and Pfeifer are certainly correct to state that, ”human beings decide at a very young age which is the preferred direction to rotate”. However, most coaches participate to a greater or lesser degree in the choice of rotation scheme of a young gymnast, as well as teaching skills and combinations. To what degree should a rotation scheme be imposed or taught to a novice gymnast?

We now know that Simone Biles is a truly unique gymnast; the greatest of all time. However, outside of the skills and routines that she performs, we do not know exactly what makes her so superior. We know that she is small; but other gymnastics champions who arguably also performed revolutionary skills are much taller, for example Svetlana Khorkina. We guess that she is exceptionally strong and powerful, but how much more than other elites, if at all? However, from Bessi and Pfeifer we have objective information about a performance trait of Biles that is truly unique: she is a pure unilateral rotating gymnast. She always rotates in the same direction, independent of the skill or body orientation in space. None of the other best in the world did this; she was the only one. And she was best. Could this be a reason that she is the best? In

what other aspects is Biles unique? And then, should we be teaching our students to turn and twist in only one direction?

On the subject of the unilateral rotating gymnast, why have no male gymnasts been identified with this pattern? Is it due to the pommel horse event that females don't perform? Finally, will this distribution of turn and twist patterns among the world's elite change? Will we see similar data four years later in the 2020 Tokyo Finals? We can only hope that Bessi and Pfeifer will continue their research.