DOES LATERALITY PREDICT TWIST DIRECTION IN GYMNASTICS?

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Abstract

Although twisting is a key element in many gymnastics skills, little is known about the relationship between twist direction in skills with different functional demands and other factors, like lateral preference. We explored relationships in twist direction between different gymnastics skills, and sought for significant predictors of preferred twist direction from measures of laterality. N = 44 gymnasts performed four different gymnastic skills. We analyzed gymnast's twist direction and lateral preference. We found that gymnasts, who twist left in upright stance, twist more often right during round-off, $\chi^2 = 13.09$, $p < .01$, and more often left during twisting somersault backwards, $\chi^2 = 17.79$, $p < .01$. Gymnasts who were either left consistent or inconsistent in eyedness showed more often a leftward turning preference in upright stance, $F(1, 42) = 10.71$, $p < .01$, and gymnasts who were more left consistent in eyedness, $F(1, 42) = 15.75$, $p < .01$, or more right-consistent in footedness, $F(1, 42) = 6.07$, $p = .02$, showed more often a rightward turning preference in the round-off. We state that as a gymnast progresses in learning, it may be wise to experiment with both twist directions to ensure that the gymnast can explore his or her turning preference with regard to lateral preference.

Keywords: *turning preference, lateral preference, round-off, twisting somersault backwards, straight jump with full turn, handstand with full turn.*

INTRODUCTION

Twisting and somersaulting make up the majority of gymnastics skills. Gymnasts decide at a very early age whether to turn to the left or to the right, and usually maintain this preference throughout their career (Arkaev and Suchilin, 2004).

While it is generally accepted in the coaching literature that an athlete should maintain his or her turning preference, one problem arises from a misperception of turning direction when being upside down, that is likely to develop in young gymnasts (Arkaev and Suchilin, 2004). One *feels* turning leftwards but is turning rightwards instead, because the vestibular system is placed upside down during an overhead phase in a particular skill. This misperception often causes problems of learning more complex skills, like a twisting somersault. Because the turning preference is often determined from self-reports of young gymnasts, indicating the direction in which they *feel good* when performing a particular skill, the actual twist direction is likely to be different between skills with different functional demands (Sands, 2000). It is furthermore likely to assume that gymnasts choose their preferred twist direction in favor of other factors, like lateral preference (Golomer, Rozey, Dizac, Mertz, and Fagard, 2009).

The purpose of this study was twofold. First, we sought to explore relationships in twist direction between different gymnastics skills with regard to turning preference in gymnasts, and second, we sought for significant predictors of preferred twist direction from measures of laterality.

There is comprehensive work done on turning preference in general and with regard to specific sports. Lenoir, Van Overschelde, De Rycke, and Musch (2006) observed for instance turning behavior in n = 107 adolescents while they ran and walked back and forth between two lines. The authors found a general preference for turning leftwards that was dependent on the experimental task. They concluded that turning preference in humans is the result of a complex interaction between intrinsic preferences and externally imposed task constraints. Golomer et al. (2009) observed the preferred direction for executing spontaneous whole-body turns. The authors recruited n = 45 untrained girls and n = 36 professional dance students. While 58% of the untrained girls showed a leftward turning bias, the remaining girls showed a rightward turning bias, independent of vision or lateral preference. The majority of dance students showed a rightward turning bias that may be explained by the influence of classical dance training. This may especially be the case because children's vestibular system is not fully mature before the age of 15 (Hirabayashi and Iwasaki, 1995), so that a "strict" training may also provoke a shift in turning preference at an early age.

Given, that there is a tendency for a leftward turning preference in humans that is, however, strongly dependent on task constraints and intrinsic factors (Lenoir et al., 2006), the question arises if such a preference can also be found in gymnastics. Sands (2000) conducted a survey on coaches, who then provided information for n = 244 gymnasts on 8 different competitive levels regarding twist direction in 5 different gymnastics skills. These skills were backward and forward twisting somersault, jump turn, pirouette, and round-off. The author found no significant difference between left and right direction of twist in any of the skills. However, the twist direction of the round-off was a significant predictor for the twist direction of the remaining four skills. Gymnasts who twist to the right during a round-off twist more often (about 74% in total) to the left in the four remaining skills and vice versa (about 64% in total). However, Sands (2000) calculated the frequencies in preferred turning directions for different skills but did not assess other parameters that may be related to twist direction.

From the coaches' perspective, restricting the turning direction for each individual gymnast does not necessarily make sense, because almost all gymnastic skills can be performed with either left or right rotation. As mentioned above, gymnasts decide at a very early age to either turn to the left or to the right, and one constituting factor for this decision could be lateral preference (Martin and Proca, 2007) because learners in general choose movement strategies in new tasks in favor of their lateral preference (Serrien, Ivry, and Swinnen, 2006). However, there is no clear evidence on the influence of lateral preference on turning preference in athletes. Brown, Tolsma, and Kamen (1983) conducted for instance a study to determine the relationship between eyedness and handedness and preferred direction of rotational movements. The authors recruited n = 120 non-athletes and n = 51 college-level gymnasts and observed turning preference in four gymnastics skills, a jump turn, a cartwheel, the swivel-hips and the seat-drop-full twist on the trampoline. Brown et al. (1983) found no consistent correlations between twist direction, and either eyedness or handedness in either experienced gymnasts or non-athletes. Golomer et al. (2009) also assessed lateral preference in their study mentioned above. Their results showed no significant relationships between turning bias and any measure of lateral preference (handedness, eyedness, footedness) in untrained girls or

professional dance students. In this context, Mohr Brugger, Bracha, Landis, and Viaud-Delmon (2003) concluded, that side preferences in lateralized whole-body movement tasks are neither comparable between tasks nor within subjects.

For instance in gymnastics, round-offs are among the first skills that a young gymnast learns. In this skill, the gymnast places one hand down while simultaneously bending his or her knee of the supporting leg. Together with the placing of the hand the supporting leg is extended, the second hand touches the ground, and the other leg is swung upwards to support the rotation. The selection of the appropriate hand together with the supporting leg is an important consideration, due to the fact that it determines the twist direction in a round-off. Results from the literature indicate, that for instance foot preference to support the body may be dependent on the context of the task rather than on lateral preference (Golomer et al., 2009; Hart and Gabbard, 1997). However, there is only marginal evidence for the choice of the supporting leg with regard to lateral preference or task context in gymnastics, so that we can only speculate about the relationship.

Our first assumption was that twist direction in upright stance (straight jump with full twist) and twist direction of round-off and handstand are inversely related in such a way that gymnasts who twist right in upright stance twist left when performing the round-off and the handstand and vice versa (Sands, 2000). Our second assumption was that twist direction in upright stance and twist direction of a somersault backwards with a full turn are related in such a way that gymnasts who twist right in upright stance twist also right when performing the twisting somersault and vice versa (Arkaev and Suchilin, 2004). Our third assumption was that lateral preference could predict preferred twist direction in gymnasts (Golomer et al., 2009).

METHODS

N = 44 female gymnasts (age: 12.3 ± 1.9 years) with more than four years of competitive experience were recruited to participate in our study. To control for possible influences on turning preference, we recruited n = 22 gymnasts, reporting a leftward turning preference in upright stance and another n = 22 gymnasts, reporting a rightward turning preference in upright stance. All gymnasts had experiences in performing single and double forward and backward somersaults with either one or two twists. The study was conducted with regard to the ethical guidelines of the German Sport University Cologne.

Gymnasts were asked to perform four different skills on the floor, as they would do in a normal training session. The four skills were: 1) straight jump with full turn, 2) round-off, 3) handstand with full turn, and 4) twisting somersault backwards on the floor (performed after a round-off and back handspring). There was neither time pressure put on the gymnasts nor additional instructions given to them. All performances were videotaped for later analysis (50 Hz digital video). Two independent expert coaches were shown the videotaped performances of all gymnasts. Their task was to judge the twist direction in all four skills of all gymnasts. Video sequences were shown on a laptop computer with the option to play backward and forward each performance frame by frame. Judged twist direction always referred to gymnast's longitudinal axis. For instance, a round-off performed with the left hand put first on the floor reflects a rightward twist about the longitudinal axis (see Figure 1).

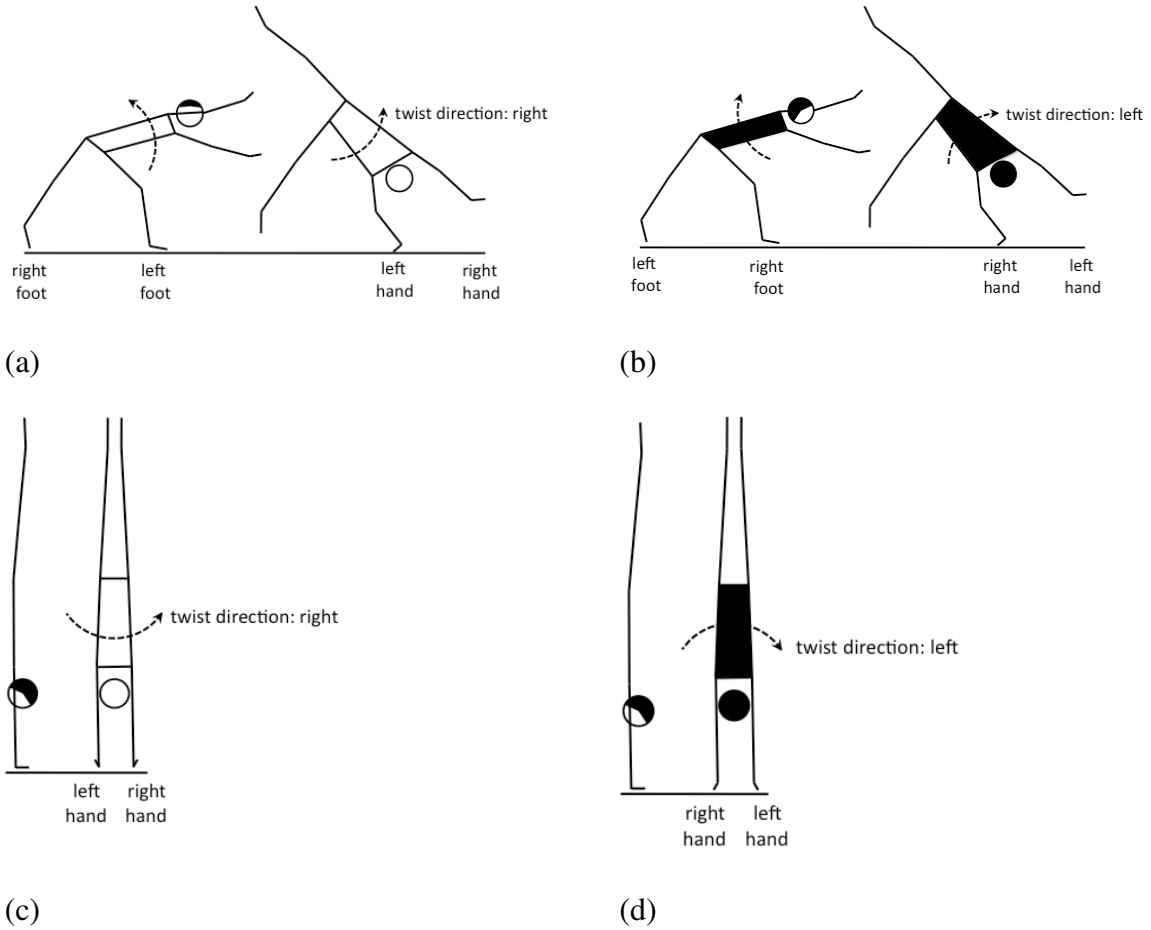

Figure 1. *Stick-figure diagrams illustrating the twist direction about the longitudinal axis (left and right) in both, the round-off (a and b) and the handstand (c and d). Notice that the back of the schematized gymnast is shown as a black area, while the front is shown as a white area.*

Inter-rater reliability between both coaches was 100%, so that twist direction of every single performance could be unambiguously classified as either left or right. Gymnast's reported turning preference in upright stance was cross-checked with their twist direction when performing a straight jump with a full turn, and matched in 100% of the cases.

Lateral Preference Inventory (LPI). To evaluate lateral preference we used a German version of the *Lateral Preference Inventory* (Coren, 1993; Ehrenstein and Arnold-Schulz-Gamen, 1997). This questionnaire assesses lateral preference in four dimensions: 1) eyedness, 2) earedness, 3) handedness, and 4) footedness. Participants are asked to respond to 16 questions related to the aforementioned dimensions, indicating their corresponding lateral preference (left vs. right). Four items assess each dimension. An example for a question related to the dimension of eyedness is: "Which eye would you use to look through a telescope?" When testing the LPI on test-retest reliability, Büsch, Hagemann, and Bender (2009) found a response consistency of 98%. The LPI takes about 10 minutes to complete. The LPI classifies a person as right-consistent, inconsistent, or left-consistent on each of the four dimensions. Additionally a sum score for each dimension can be calculated, ranging from -4 (left-consistent type) to 4 (right-consistent type) with a zero value indicating an inconsistent type.

The procedure of our study consisted of three phases. In the first phase, the gymnasts arrived at the gymnasium and were introduced to the purpose of the study.

After given their written, informed consent, they were asked to warm-up and prepare themselves for a floor training session, like they would do in normal training. In the second phase, and after warming-up, gymnasts were asked to perform the aforementioned four gymnastics skills in their preferred sequence. They could rest at free will and there was no time pressure put on them. During performance, they were videotaped. In the third phase, and after performing all skills, gymnasts were asked to complete the LPI. After completing the LPI, gymnasts were debriefed and received a chocolate bar for their participation. The complete investigation took about 30 minutes for each participating gymnasts.

An overall significance criterion of α = 5% was established for all results reported. To examine relationships between preferred twist direction in different gymnastic skills, we conducted separate frequency analyses, taking the twist direction frequencies of upright stance, round-off, handstand, and twisting somersault backwards as dependent variables. Because we calculated χ^2 –tests of every combination of two of the aforementioned skills, this resulted in six separate analyses. To examine differences in measures of laterality with regard to twist direction, we calculated separate multivariate analysis of variance (MANOVA) for preferred twist direction in each of the aforementioned gymnastic skills, taking the laterality scores for eyedness, earedness, footedness, and handedness as dependent variables. In case, the MANOVA showed a significant overall effect, we calculated the separate univariate ANOVAs for each of the dependent variables to explore the structure of the overall effect.

RESULTS

Preferred Twist Direction and Gymnastic Skills

Our first assumption was that twist direction in upright stance (straight jump with full twist) and twist direction of round-off and handstand are inversely related in such a way that gymnasts who twist right in upright stance twist left when performing the round-off and the handstand and vice versa. Our second assumption was that twist direction in upright stance and twist direction of a somersault backwards with a full turn are related in such a way that gymnasts who twist right in upright stance twist also right when performing the twisting somersault backwards and vice versa.

We conducted separate frequency analyses, taking the twist direction frequencies of upright stance, round-off, handstand, and twisting somersault as dependent variables. The analysis revealed a significant effect for twist direction in round-off, χ^2 = 13.09, p < .01, confirming our first assumption. Gymnasts, who twist left in upright stance, twist more often right during round-off and vice versa (see Figure 2a).

Unexpectedly the analysis revealed no significant effect when comparing twist direction in upright stance and in handstand, χ^2 = .09, p = .76. Gymnasts, who twist left in upright stance, do not twist more often right during handstand and vice versa (see Figure 2b). The analysis revealed another significant effect, when comparing twist direction in upright stance with twist direction in twisting somersault, χ^2 = 17.79, p < .01. Gymnasts, who twist left in upright stance twist more often left during twisting somersault backwards and vice versa (see Figure 2c).

When comparing twist direction in round-off with twist direction in handstand or in a twisting somersault, we found no significant effects, χ^2 = .82, p = .36, and χ^2 = 3.27, p = .07 respectively (Figure 2d and 2e).

(f).

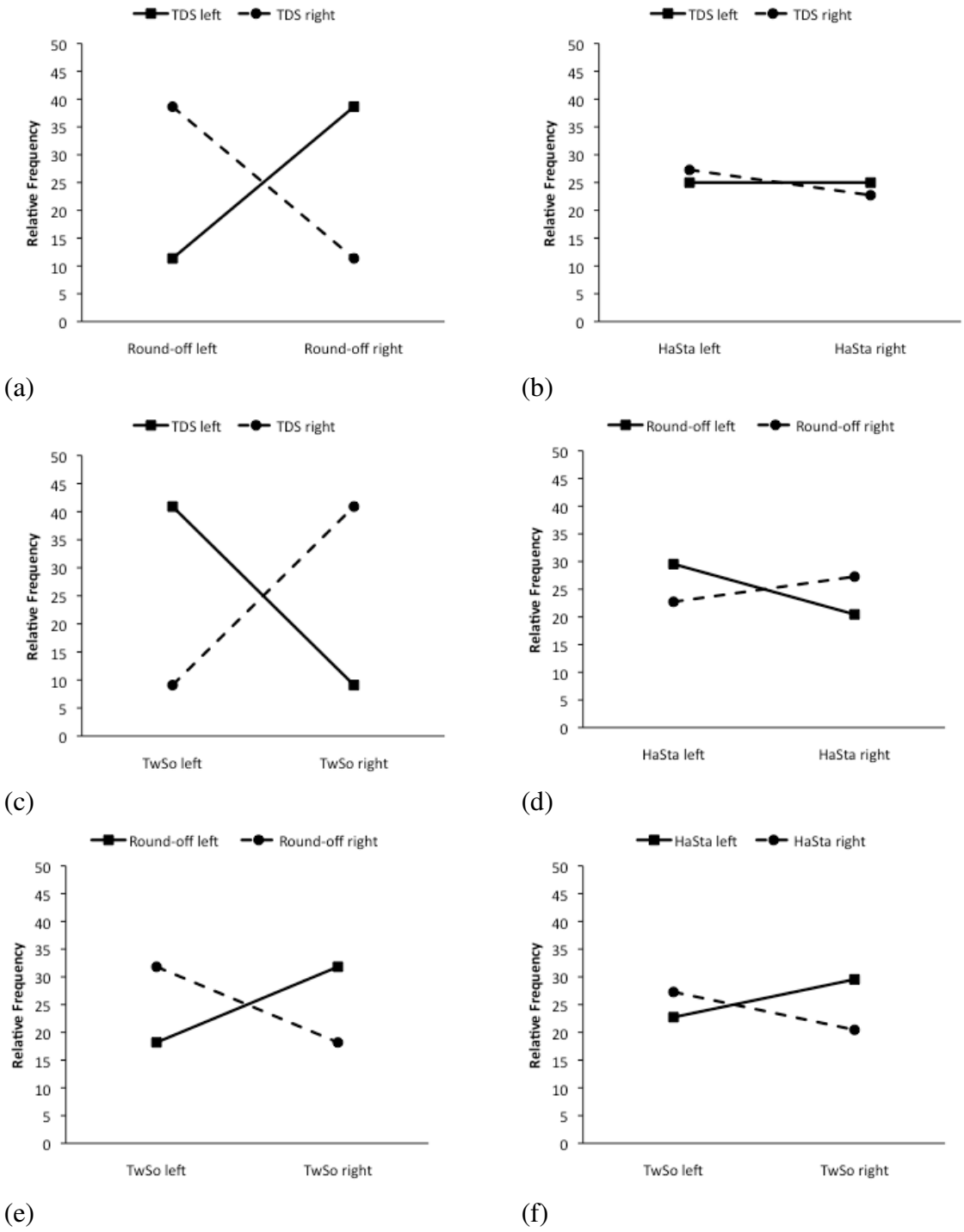

Figure 2. *Relative frequencies of gymnast's twist directions in upright stance (straight jump with full turn, TDS) compared to their twist direction in the round-off (a), the handstand (HaSta, b), and in the twisting somersault (TwSo, c), twist direction in round-off compared to handstand (d), twisting somersault (e), and twist direction in handstand compared to twisting somersault*

Finally, when comparing twist direction in handstand with twist direction in a twisting somersault, we found no significant effect, $\chi^2 = .82$, $p = .36$ (see Figure 2f).

Laterality and Preferred Twist Direction

Our third assumption was that laterality could predict preferred twist direction in gymnasts. A multivariate analysis of variance (MANOVA) was

conducted for preferred twist direction in each of the aforementioned skills, taking the laterality scores (LPI) for eyedness, earedness, footedness, and handedness as dependent variables. The MANOVA for preferred twist direction in upright stance showed an overall effect, Wilk's $\lambda = 0.76$, $F(4, 39) = 3.19$, $p = .02$. However, when inspecting the separate univariate ANOVAs, the effect occurred only for eyedness, $F(1, 42) = 10.71$, $p < .01$, but neither for footedness, handedness, nor earedness. The MANOVA for preferred twist direction in round-off showed an additional overall effect, Wilk's $\lambda = 0.67$, $F(4, 39) = 4.74$, $p < .01$, that occurred for eyedness, $F(1, 42) = 15.75$, $p < .01$, and footedness, $F(1, 42) = 6.07$, $p = .02$. The MANOVAs for preferred twist direction in handstand or twisting somersault reached no statistical significance, Wilk's $\lambda = .97$, $F(4, 39) = 0.22$, $p = .92$, and Wilk's $\lambda = .89$, $F(4, 39) = 1.12$, $p = .34$.

Gymnasts who were more left consistent or inconsistent in eyedness showed more often a leftward turning preference in upright stance whereas gymnasts who were more right-consistent in eyedness exhibited more often preference for rightward rotations. Gymnasts who were more left consistent in eyedness or more right consistent in footedness showed more often a rightward turning preference in the round-off.

CONCLUSION

The purpose of our study was twofold. First, we sought to explore relationships in twist direction between different gymnastics skills with regard to turning preference in gymnasts, and second, we sought for significant predictors of turning preference from measures of laterality. We recruited female gymnasts with more than four years of competitive experience, and observed their twist direction in four different gymnastic skills together with their lateral preference in four dimensions. We found that gymnasts who twist left in upright stance, twist more often right during round-off, and more often left during twisting somersault backwards and vice versa. There was no relationship between twist direction in upright stance and in handstand. Gymnasts who were either left consistent or inconsistent in eyedness showed more often a leftward turning preference in upright stance whereas gymnasts who were more right-consistent in eyedness exhibited more often preference for rightward rotations. Gymnasts who were more left consistent in eyedness or more right consistent in footedness showed more often a rightward turning preference in the round-off.

Extending the results of Sands (2000), there is a clear pattern of preferred twist direction between different skills that may in part be explained by perceptual similarity and lateral preference. Perceptual similarity may explain the relationship of twist direction between round-off, twisting somersault and straight jump with full turn with regard to the learning process in gymnastics (Arkaev and Suchilin, 2004). Both, the round-off and the straight jump with full turn are learned early in a gymnast's career. Perceptual similarity may occur when a gymnast rotates to the left in upright stance and to the right when being in an overhead position, so that the vestibular information is similar (Von Laßberg, Mühlbauer, and Krug, 2003). The gymnast *feels* that he or she maintains twist direction but instead rotates in different directions in both skills.

The same mechanism can explain the relationship between twist direction in a straight jump with full turn and in the twisting somersault. Especially in artistic gymnastics a twisting somersault is learned in such a way that the gymnast initiates the twist in the first half of the flight phase (before reaching an overhead position), again, the vestibular signal regarding the longitudinal axis is similar in both skills, this time indicating the same twist direction. However, there was no clear relationship between twist direction in a straight jump with full turn and a handstand, between twist direction in handstand and round-off,

nor between twist direction in handstand and twisting somersault. Because the handstand with a full turn is a more static skill in which the gymnast has the goal to maintain equilibrium, he or she may rely to a lesser degree on vestibular information, but rather on information from other sensory sources, so that a clear relationship between the twist direction in more dynamic skills and the handstand with a full turn may not emerge in the learning process (Asseman and Gahéry, 2005).

According to lateral preference we found significant relationships for eyedness and the preferred twist direction in upright stance as well as for eyedness and footedness and the preferred twist direction in round-off. These results are contrary to the findings of Brown et al. (1983) or Golomer et al. (2009) who found no clear relationships between lateral preference and turning preference in athletes. Especially in gymnastics, athletes decide at a very early age to either turn to the left or to the right or usually maintain this preference throughout their whole career. One constituting factor for this decision could be lateral preference (Martin and Proca, 2007), because learners in general choose movement strategies in new tasks in favor of their lateral preference (Serrien, Ivry, and Swinnen, 2006). Furthermore, specific dimensions of lateral preference are already developed before gymnasts start to learn more complex movements. Apparently other extrinsic or intrinsic factors may also explain the selection of twist directions in different skills (Hart and Gabbard, 1997; Previc, 1991). However, the emergence of laterality is for instance linked to vestibular asymmetry and may be one constituting factor in choosing to rotate either left or right in specific gymnastic skills.

There are several limitations of our study so far and we want to highlight two specific aspects. First, we recruited our sample in such a way that 50% of the participants showed a leftward turning preference in upright stance while the remaining 50% of the participants showed a rightward turning preference. This selection does not assure that also lateral preference is equally distributed throughout the sample. However, we used the LPI that does not only classify participants as either left- or right-consistent on a specific factor but rather a distinct score is calculated, that indicates lateral preference on a continuum ranging from -4 (left-consistent) to 4 (right-consistent), allowing for gradual judgments according to laterality even if a sample is not equally in lateral preference (Büsch et al., 2009). However, if we would for instance equally select left- and right-handed gymnasts in another sample of the same expertise level and search for differences in turning preference, the effect should be even stronger.

Second, we acknowledge that our study is very exploratory in nature by describing relationships between preferred twist direction in different skills and lateral preference. However, there is still a fundamental discussion if an experimental manipulation of preferred twist direction should at all be conducted in gymnastics, because this could lead to negative developments for the individual gymnast if this manipulation significantly constrains his or her spatial perception in complex skills. From this point of view it is more beneficial to explore the relationships between a naturally selected preferred twist direction and the underlying factors. This could, in a subsequent step, be done in twins who practice in gymnastics but who show for instance a different turning or lateral preference. The ultimate goal could be the development of a complex test series to predict the optimal configuration of twist directions in different gymnastics skills for each individual gymnast on the basis of his or her characteristics in different factors, like lateral preference.

There are some practical implications of our study so far. First, according to our results, turning preference in gymnastics depends on the demands of the task and, in part, on lateral preference. With regard to the long-term training schedule the coach should carefully decide when to intervene in the development of

twisting preference. For instance on the vault, the Tsukahara and the Kasamatsu begin with a round-off like movement to a support phase on the vaulting table, followed by either a counter-rotation or a continued rotation about the longitudinal axis. With regard to the learning history of an individual gymnast, either the Tsukahara or the Kasamatsu will be easier for him or her to acquire because he or she can maintain his or her preferred twist direction in the after flight phase.

We further acknowledge that the relationships we found are not applicable to all gymnasts, and therefore do not allow rule-like assessment. We agree with Sands (2000), stating that as a gymnast progresses in learning, it may be wise not to constrain twist direction but rather to experiment with both directions to ensure that the gymnast has the opportunity to *explore* his or her (natural) preference. It could furthermore be wise to explain the gymnast the potential misperception when being overhead and confront him or her with videotape replays of his or her performance so that he or she can relate his or her perceived twist direction with the actual twist direction.

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