The relationship between motoric dominance and functional dominance while executing judo techniques: a study on laterality

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Abstract

Background & Study Aim: Motoric Dominance is defined as the preferential use of an upper or lower limb in a variety of common tasks, while the term Functional Dominance refers to laterality evidenced by performing different specialised sport techniques.

The main purposes of this study were knowledge about the relations between motoric dominance and functional dominance in a group of high-level Spanish judokas significantly diversified in terms of the age and the training experience. We solve the three research tasks: 1) to assess laterality of hand, foot/leg and preference in turning (i.e., motoric dominance); 2) to assess the preferences (right-dominant, left-dominant, or symmetrical) while executing three specific judo techniques (uchi mata, seoi nage and o soto gari) (i.e. functional dominance); 3) to analyse the relationship between motoric dominance and functional dominance.

Material & Methods: The sample was composed of 64 high-level Spanish judokas (39 males and 25 females). Their average age and training experience were 19.5 years (range 16–28) and 10.3 years (range 7–18), respectively. Besides descriptive statistics (percentages of motoric and functional dominance), the categorical data were analysed with a Pearson chi square (p-value ≤ 0.05); when the relation was significant the adjusted residuals were also analysed. The strength of association was calculated with the corrected contingency coefficient (C_{corr}).

Results: Motoric dominance for hand was 7.8% (left-handers), for foot/leg 15.6% (left-footers) and preference in turning was 23.4% (left-turn). The analysis of functional dominance showed that the vast majority of the observed judokas presented right dominance (66–86%) for executing specific judo techniques. Finally, no relationship ($p > 0.05$) was detected in 8 out of 9 evaluated associations between motoric and functional dominance. We only found an association ($p = 0.027$) between motoric dominance of turn and execution of o soto gari.

Conclusions: These results suggest that laterality expressed as functional dominance is likely to be acquired through specific practice of judo motor skills.

Keywords: combat sports • handedness • judo motor skill

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Laterality - The tendency to use preferentially the organs (hand, foot, ear, eye) of the same side in voluntary motor acts.

Handedness – The concept of handedness typically refers to the hand preferentially used for a simple or complex motoric activity, i.e., the tendency to use one hand more skilfully or in preference to the other.

Introduction

The preferential use of an upper or lower limb has been called *motoric dominance* [1]. This concept refers to the usual measures of laterality when examining which hand or foot is preferentially used in a set of situations. Most general tests of laterality (i.e. indexes commonly used to assess or estimate handedness) are designed to evaluate *motoric dominance* [2-6]. In contrast, the term *functional dominance* refers to laterality demonstrated by the preference with which the athlete executes different sport skills.

The concept of handedness is a more specific term, and typically refers to the hand preferentially used for a simple or complex motoric activity [7, 8]. The percentage of the left-handed population is around 6–13%, and left-handedness in men is more common than in women [9].

Many authors have focused on the over-representation of left-handers in certain sports such as tennis, fencing, judo, wrestling and boxing compared to the general population [10-13]. Wood and Aggleton [14] reported that left-handers (or left-footers) appear to be more common in what are called *fast ball* sports (19.5%, n = 322). Left-handers' (or left-footers') over-representation also prevails in *non-interactive* sports like golf [14] and in *interactive* or *confrontational* sports [15-18].

The existence of a higher percentage of left-handers in certain sports has been generally attributed to a greater chance of success [1, 11-13, 17, 19]. However, some disagreements exist on the reason that determines this sporting success [12, 16, 17].

Some authors have presented a genetic or innate hypothesis for higher performance (*Innate Superiority Hypothesis*) [5, 7, 10] while other authors defend the strategic hypothesis (*Strategic Advantage Hypothesis*), which describes a different source for the success of left-handed athletes [1, 9, 11-15, 17]. The *strategic advantage hypothesis* explains success by environmental factors (tactical and/or strategic) associated with handedness during sporting interactions [14] or by the so-called *fighting hypothesis* [9].

Laterality in sports is typically determined by validated and verified tests or self-reported use of hand, foot, eye, ear preference, and/or surveys, such as the Edinburgh Handedness Inventory [2], Harris Test for dominance laterality [3], Purdue Pegboard Test for manual dexterity and bimanual coordination, etc. These tests allow a classification of athletes in terms of laterality, but they do not assess functional skill dominance. Thus, a higher probability of sport success might not be associated with standard classification as a left- or right-hander based on tests and indexes commonly used to assess or estimate handedness, but a higher probability of sport success might be due to an advantage from functional skills being executed on the left side.

The main purposes of this study were knowledge about the relations between *motoric dominance* and *functional dominance* in a group of high-level Spanish judokas significantly diversified in terms of the age and the training experience. We solve the three research tasks: 1) to assess laterality of *hand*, *foot/leg* and *preference in turning* (i.e., *motoric dominance*); 2) to assess the preferences (right-dominant, left-dominant, or symmetrical) while executing three specific judo techniques (*uchi mata*, *seoi nage* and *o soto gari*) (i.e. *functional dominance*); 3) to analyse the relationship between *motoric dominance* and *functional dominance.*

Execution dominance of specific judo actions (*functional dominance*) and indexes commonly used to assess or estimate handedness (*motoric dominance*) were evaluated in a sample of 64 judokas.

It was hypothesised that there is *no relationship between being right or left-hander, right or left-footer and right, left or without preference in turning (motoric dominance) and executing Judo techniques as right, left or symmetrical dominance (functional dominance).*

Material and methods

Participants

The sample was composed of 64 athletes (39 males and 25 females) who had won a medal in the Galician Judo Championship (Spain) (juvenile men, junior men and women, and senior men and women categories). Their average age and training experience were 19.5 years (range 16–28) and 10.3 years (range 7–18) respectively (all of them black belts). All participants were volunteers and gave written informed consent, and the study had ethical clearance according to the institutional guidelines (University of A Coruña, Spain).

Measures and Procedures

Motoric dominance

We chose items from tests that have been commonly used to determine the laterality of hand, foot and turn:

Hand [2, 3, 20]: *Compared handwriting*; additionally we also scored time and quality of writing, and participants were clearly defined as right or left-handed. *Ball throw* (15 cm in diameter) against a square (1 m^2, 1 m above the ground, at a distance of 2.5 m) painted on a wall; we also scored lateral performance, compared skill (15 throws with each hand), and speed (time). The possibilities were right-handed, left-handed, or without hand predominance. *Attack-striking gesture* or spontaneous gesture against a soccer ball (a distance of 40–70 cm) and at the level of face. The subject had 3 attempts (or 5 if the subject changed the hand). The possibilities were right-handed, left-handed, or without hand predominance.

Foot/Leg [3]: *Ball kick* (soccer ball with a diameter of 70 cm) on target (a square 1.5 m^2, 1 m above the ground, at a distance of 2.5 m). We scored lateral performance, compared skill (10 kicks with each foot/leg), and speed (time). The possibilities were right-footed, left-footed, or without foot predominance. *Unipodal horizontal jump*, we scored the take off leg (the opposite to the supporting leg) in 3 attempts (or 5 if the subject changed the leg) and the jump distance. The possibilities were right-footed, left-footed, or without foot predominance. *Back-heel gesture* or spontaneous gesture for the low limb, wherein *the subject had to hit the ground as if to crack a nut*. We scored the leg for 5 attempts. The possibilities were right-footed, left-footed, or without foot predominance.

Turn [4, 6, 21] (counter clockwise rotation meant right-turn; clockwise rotation meant left-turn): *From supine position, get up and run 5 meters in the opposite direction*, i.e. lying facing up behind the mark on the ground, the subject had to get up turn 180º, and run 5 m in the opposite direction to another mark (5 attempts in all cases). We scored the direction of turn and the time; the possibilities were right-turning preference, left-turning preference, or without preference in turning. We also developed the *turning dominance index* by granting 1 point to each attempt with the result of counter clockwise rotation, and 0 points if the result was clockwise rotation. We calculated the ratio (quotient) between this value and the total number of attempts, obtaining the *turning dominance index*. The index values of the interval (0–0.33) were considered as *left-turning preference*, (0.34–0.66) as *without preference in turning*, and (0.67–1) as *right-turning preference*. The same procedure was used in the following two tests: *From a standing position, rotate 180º without moving your feet* (based on decisional criteria and speed execution); the subject (standing position) is leaning with their hands on the wall (arms semi-flexed) and, on the signal, had to turn. We scored the direction of turn (5 attempts in all cases) and the possibilities were right-turning preference, left-turning preference, or without preference in turning. *From a standing position, jump and turn 360º*; the subject is standing in the middle of a delimited square (1 m x 1 m), on the signal they had to jump vertically, turn 360º and land inside the square. We scored the direction of turn and landing characteristics (balance and spatial area). The possibilities were right-turning preference, left-turning preference, or without preference in turning.

Functional Dominance (i.e. laterality measured by executing specific judo techniques)

We selected three specific throw techniques: *seoi nage* (two arm shoulder throw), *uchi mata* (inner thigh trow), and *o soto gari* (large outer reap). Additionally, we used two criteria to measure the laterality preference executing these motor skills: for actions (typically a throw) involving a turn before the execution (*seoi nage* and *uchi mata*) laterality was defined by the *direction of rotation*, thus when the right shoulder turned to the left, it was defined as a right execution (counter clockwise); if the left shoulder was directed to the right, it was defined as a left execution (clockwise); when the movement was executed without a previous turn (i.e., with one supporting leg, as in *o soto gari*) we defined the laterality of the athlete based on the dynamic leg (i.e., the opposite of the supporting leg).

The procedure for measuring the *functional dominance* was as follows:

Warm up by executing judo techniques *freely* (maximum 10 minutes both) with the partner. There were no instructions, except that each of the judokas had to execute (in 60 sec and alternately), at least, the 3 judo techniques. No observations were made.

Specific observation, to analyse specific motor behaviour in the execution of these judo techniques with the partner *as in competition*. The instructions were: *you must execute seoi nage (uchi mata* and *o soto gari) as in a competition*. The possibilities were right-dominant or left-dominant. We observed and scored the laterality of executions (right-dominant or left-dominant). Judokas had to execute, at least, 7 times the same technique; performing 6 times on the same side (right or left) meant *functional dominance* executing that technique (if not, they had to execute 5 times more, i.e., 12 times). Thus, 12, 11, 10, 9, 3, 2 or 1 of the same lateral executions meant right- or left-dominance, and 8, 7, 6, 5, 4 of the same lateral executions meant symmetrical *functional dominance* executing that technique. The final possibilities were right-dominant, left-dominant, or symmetrical.

After analysing the execution type for each one of the three techniques we determined whether the judoka was right-dominant, left-dominant, or symmetrical executing these techniques.

The analysis involved 18 relationships (i.e. combinations of hand, foot/leg and turn, and three judo motor skills) and 63 cases (i.e. combinations between 7 possibilities for *motoric dominance*, 3 for *functional dominance* and 3 judo techniques).

In section "r*elationship between motoric dominance and functional dominance*" we have analysed 9 relations between variables (and 63 possibilities, i.e. combinations between 7 possibilities for *motoric dominance*, 3 for *functional dominance* and 3 judo techniques) regarding the association between *motoric dominance* and *functional dominance*:

The overall results are presented combining across age, sex, or weight for all the judokas.

Statistical Analysis

SPSS version 15.0 software (SPSS, Inc., Chicago, IL, USA) was used to analyse the data. Besides descriptive statistic (percentages), the Pearson *chi-square* test was performed to analyse the association between *motoric dominance* and *functional dominance*. To assess the strength of association (*effect size*) the *corrected contingency coefficient* (C_{corr} 0–1) was calculated. Significant level was set at p-value ≤ .05. When a significant association was detected, *adjusted residuals* (*AdjR*) were analysed; an absolute value of the *AdjR* higher than 1.96 was considered significant.

Results

Motoric dominance

Laterality values of hand, foot and turn (*motoric dominance*), and the crossed laterality hand-leg, hand-turn, leg-turn and hand-leg-turn (crossed *motoric dominance*) are presented in Table 1.

Functional dominance

The values for laterality executing *uchi mata, seoi nage* and *o soto gari* are presented in Table 2.

Table 1. *Motoric Dominance* (hand, foot and turn), and *Crossed Motoric Dominance* (hand-leg, hand-turn, leg-turn and hand-leg-turn).

HAND		LEG		TURN		
Right	Left	Right	Left	Right	Left	Without Preference
92.2%	7.8%	84.4%	15.6%	67.2%	23.4%	9.4%

HAND-LEG (Crossed Motoric Dominance Hand-Leg)			
Right-Right	Right-Left	Left-Right	Left-Left
81%	11%	3%	5%

HAND-TURN (Crossed Motoric Dominance Hand-Turn)					
Right-Right	Right-Left	Right-W. Preferen.	Left- W. Preferen.	Left-Right	Left-Left
62%	21%	8%	2%	5%	2%

LEG-TURN (Crossed Motoric Dominance Leg-Turn)					
Right-Right	Right-Left	Right-W. Preferen.	Left-W. Preferen.	Left-Right	Left-Left
58%	21%	6%	3%	9%	3%

HAND-LEG-TURN (Crossed Motoric Dominance Hand-Leg-Turn)					
R-R-R	R-R-L	R-R-W. Preferen.	R-L-W. Preferen.	R-L-R	R-L-L
55%	20%	5%	3%	6%	2%
L-R-R	L-R-L	L-R-W. Preferen.	L-L-W. Preferen.	L-L-R	L-L-L
2%	0%	2%	0%	3%	2%

Table 2. Functional dominance *uchi mata, seoi nage* and *o soto gari*

Uchi mata-Right Dominance	Uchi mata-Left Dominance	Uchi mata-Symmetrical
86%	14%	0%
Seoi nage-Right Dominance	Seoi nage-Left Dominance	Seoi nage-Symmetrical
66%	17%	17%
O soto gari-Right Dominance	O soto gari -Left Dominance	O soto gari-Symmetrical
80%	9%	11%

Relationship between motoric dominance and functional dominance

Statistically, one relation was significant (hence dependent), while eight (62 possibilities) were *non-significant* (hence independent) relations (Table 3).

Relationship between motoric dominance and functional dominance executing uchi mata

We found no relation between *motoric dominance* (hand, foot/leg or turn) and the execution of the *uchi mata* judo technique (*functional dominance*) (*p-value* = 0.691, 0.557 and 0.559, respectively). This means that *functional dominance* was statistically independent of *motoric dominance* for the execution of this motor skill (Table 3).

Relationship between motoric dominance and functional dominance performing seoi nage

We noted no relation between *motoric dominance* (hand, foot/leg or turn) and the execution of the *seoi nage* judo technique (*p-value* = 0.331, 0.462 and 0.696, respectively); therefore, the variables were independent, and *functional dominance* was statistically independent of *motoric dominance* for the execution of this motor skill (Table 3).

Relationship between motoric dominance and functional dominance executing o soto gari

We found no relation between *motoric dominance* of the *hand or foot/leg* and the execution of the *o soto gari* judo technique (*functional dominance*) (*p-value* = 0.052 and 0.596 respectively); therefore, these variables were independent. We found an association (*p-value* = 0.027) between *motoric dominance* of *turn* and execution of the *o soto gari* (i.e. *motoric dominance* dependence). The analysis of the *adjusted residuals* (*AdjR* = 3.23) indicated that the frequency of finding judokas without a preference in turning when executing *o soto gari* as symmetrical was much higher than expected by chance (Table 3).

DISCUSSION

Regarding *motoric dominance*, the results (Table 1) for *hand and foot/leg* (6–13%) do not differ from those reported by other authors for left-handers and left-footers in the general population [9, 13], even considering that our subjects were elite athletes. The preference in *turning* also showed similar values to those found by other authors [4, 21] and, concerning the analysis between upper and lower segments, we found that the distribution remains favourable to the pattern right-right as reported by other authors (80–85%). Between limbs and *turn* it still shows a higher percentage of right-right formula, although less than in the analysis above (*hand*

Table 3. Relationship between motoric dominance, and functional dominance executing judo techniques
X^2 = Chi square; p = p-value; DF = Degree of Freedom; C_{corr} = Effect Size; AdjR = Adjusted Residuals

	Motoric Dominance HAND	Motoric Dominance FOOT/LEG	Motoric Dominance TURN		
Functional Dominance Uchi mata	X^2=0.158 p=0.691 DF=1	X^2=0.346 p=0.557 DF=1	X^2=1.163 p=0.559 DF=2		
Functional Dominance Seoi nage	X^2=2.210 p=0.331 DF=2	X^2=1.545 p=0.462 DF=2	X^2=2.216 p=0.696 DF=4		
Functional Dominance O soto gari	X^2=5.914 p=0.052 DF=2	X^2=1.034 p=0.596 DF=2	X^2=10.921 p=0.027* C_{corr}=0.468 DF=4		
			Right	Left	No Prefer
			AdjR	AdjR	AdjR
NT-LB1 Right Dominant			0.39	0.76	-1.86
NT-LB1 Left Dominant			0.92	-0.36	-0.88
NT-LB1 Symmetrical			-1.48	-0.61	3.23*

and *leg*), which confirms that the hand preference is more linked to the use of leg (81%) than to the use of turn (62%).

It might be considered that laterality should not be used as a general concept, but only be referred to in connection to a particular skill or task (sporting or not). Wang [22] has already suggested that the *dominant hand* does not necessarily dominate all performances, and he questions what tasks or skills dominate the dominant hand, since it seems that the functional superiority of the hand varies with the task. Our results also support findings on leg preference being task-dependent and that there is no such thing as *the preferred* leg or *the dominant* leg [23].

Regarding *functional dominance* (i.e. laterality executing judo techniques) (Table 2), 86% of the judokas were right-dominant while executing the *uchi mata* judo skill. What is surprising is that the most interesting data in frequencies is the absence of judokas (0%) who performed this action symmetrically. It is possible that the complex structure of this technique (rotation, one leg support, grip, performance, etc.) does not facilitate symmetric learning or symmetric execution to the judoka. This technique requires complex movements and adaptive coordination of its elements, such as relative position, initial performance conditions, or the settings of the movement in match-ups, especially during actual execution in a competition or free practice.

Regarding *seoi nage* a 17% higher frequency of symmetric performance in comparison with *uchi mata* (0%) was found, while the frequency of left-dominant execution was similar between techniques (14% vs. 17%). It can be concluded that judokas performed *seoi nage* as right-dominant less often than *uchi mata* (although both techniques require turning) and the symmetric behaviour was more frequent for *seoi nage*. This is an interesting finding since symmetric performance represents a success criterion in judo for several authors [15, 19].

Ultimately, the execution of the *o soto gari* judo skill was strongly right-dominant (*functional dominance*), and very similar to the execution of *uchi mata* (80% and 86%, respectively). In our opinion the execution features of *uchi mata* – which are determined by a specific mechanical performance [24], by a particular grip, by the position, or by one supporting leg – are very similar to the execution characteristics of *o soto gari*, except for the structure of the turn. Both of these techniques are not as different as they may appear, and therefore they reflect similar laterality biases (*functional dominance*) during execution.

In summary, the analysis of *functional dominance* showed that the vast majority of the observed judokas presented right dominance for executing specific judo actions (both with and without a turn).

The relative positions between judokas (i.e. the relationship between the side of execution and the position of the opponent) also seem to be important, and it has been pointed out that relative positions in judo relate to competition outcomes. Weers [25] reported that 48% of the matches had a clearly asymmetric structure (right-dominant vs. left-dominant positions), whereas only 10% had a symmetric structure (right-dominant vs. right-dominant, or left-dominant vs. left-dominant). Moreover it was also reported that combat stance orientation is related to skill and success in other sports of combat: southpaw fighters had a greater number of fights than those using an orthodox stance [18]. All these data might indicate the relationship between relative positions, laterality executing judo techniques (*functional dominance*) and success.

Several authors [11, 12, 15] have already suggested that laterality, specifically *functional dominance*, and success are closely related in judo, which reinforces the hypothesis that in certain sports [9], and especially in judo [19], a symmetric execution can be a synonym for success. This is especially important when analysing the laterality of judokas executing judo techniques because, many times, that *functional dominance* (i.e. to execute as right- or left-dominant) could be directly linked to the relation between the opponent's position (right or left position) and the particular technique that the judoka needs to perform.

Finally, through the analysis of the relationship between *motoric dominance* and *functional dominance* executing the *uchi mata, seoi nage* and *o soto gari* judo techniques, and in light of the results, we could note that there was only statistically significant dependence between *motoric dominance* and *functional dominance* in one case (out of 63), and it was for turning. This means, primarily, that the laterality for executing specific judo actions did not depend on the tested laterality of the hand, foot/leg or turn (*motoric dominance*).

Previously, a relationship between left-handed wrestlers (assessed with the Edinburgh Handedness Inventory) and sporting success has been reported [12]. However this study did not reveal if the wrestlers' left-handedness is related to a preferred executing body side of fighting (left or right), or not. The same method was used to determinate the relationship between left-handedness and success in boxing [10] and, once again, the left-handed boxers (assessed by the Edinburgh Handedness Inventory) were more successful, but the same question remains. For that reason, we consider that it is necessary to know how the relationship between morphological (innate or spontaneous) laterality and learned laterality is. According to the results obtained in a population of athletes, 7% had shown opposite preferences between hand gestures (used in common gestures) and sporting performances; furthermore, that percentage increased up to 26.6% for the lower body [5].

In taekwondo [26] *dominant motoric abilities* (similar to *motoric dominance* in our study) were measured; most of them were right-handed/footed but this did not relate to the performance of taekwondo leg techniques. In another study involving 90 judokas [11] handedness and footedness were determined, by declaration, to establish the relationship with four directions of throw (forward-right, forward-left, back-right and back-left), however, in this case, the author reported a discrepancy between declared and actual handedness and footedness of the athletes. Other authors [27] also suggested that during motor and postural skill acquisitions (long-term judo training) lateral preferences are modified, probably due to neuroplasticity, which could explain our results and the independency relations that we have proposed in this study.

All of this could also justify, in certain cases, the unnecessary nature vs. nurture debate [1, 16] because both theories would be present, suggesting the hypothesis of a double fragmentation in the genesis of the laterality structure which, on the one hand, would present an innate factor and, on the other hand, an educational factor that is expressed through the *laterality of use*.

There are several potential limitations in the current study. Firstly, the sample was only 64 people and secondly we obtained the *functional dominance* data in training conditions, not in competition. However we think that the approach, design and results can be considered for further investigations.

Conclusions

We assessed the relationship between the test assessment laterality (*motoric dominance*) and the functional execution of techniques (*functional dominance*), based on the assumption that they could be different. Our results point out that being labelled left-handed (or right-handed) and having sporting behaviour as left-dominant (or right-dominant) are different issues. Therefore, the reason for a higher probability of sporting success associated with laterality might not be due to be a right- or left-hander (determined by indexes commonly used to assess or estimate handedness), but due to executing on the right or left side (i.e. as a right or left-dominant athlete).

If success in judo is related to the type of laterality of performance, or *functional dominance*, and this is not strongly related to *motoric dominance*, then this specific manifestation of executing has been acquired (consciously or unconsciously) and therefore, the motor learning process or sport training could be used to modify the *functional dominance* as required.

This study might also have applications for training and competitions in judo. Based on the negative frequency-dependent selection hypothesis [9], specialisation and preparation of judokas to take advantage of the laterality of match-ups could increase their chances of success. Therefore, the idea, presented in literature, of a potential *construction of judokas* (and other athletes) specialised in certain movements or sport behaviours, based on *functional dominance*, could also modify the incidence of the results based on the frequency-dependent selection hypothesis, especially in sport.

Finally, we are also conscious that the direction of causality [16] should be analysed and specified, i.e. if a particular *motoric dominance* predisposes a person to choose certain sports or not, or if sporting practice can influence *motoric dominance*, which is also an important issue regarding studies of laterality.

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