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Research article

Both Unopposed and Opposed Judo Tasks are Suitable for Analyzing Changes in Lateral Preference

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Abstract
Judo coaches aim to develop left-handed techniques in right-handed judoka due to a potential frequency-dependent strategic advantage during competition. Thus, easily completed tasks are needed to track the progression of the lateral preference index (percentage as right-handed actions). Thirty naïve volunteers performed two tasks, an unopposed repetition-based dynamic task (*yakusoku geiko*) and an opposed-bouts task (*randori*), before and after eight-week training protocols differing in the executing side. Training protocols consisted of a control group (without any instruction regarding the practice side), a bilateral group (practicing with both dominant and nondominant sides), and a nondominant group (practicing exclusively on the nondominant side). ANOVA-type tests were used for analyzing the suitability of the unopposed repetition-based dynamic task for detecting changes in the lateral preference index and for analyzing the concordance between tasks. Additionally, concordance was tested with Spearman's rank correlations and Bland-Altman plots. Lower lateral preference indices (i.e., reductions of executions as right-hander) were observed after training in the nondominant group and in comparison with the control group and bilateral group on the posttest ($p < 0.05$). ANOVA-test for concordance analysis revealed no differences between tasks ($p > 0.05$) with significant correlations ($p < .05$) and low bias during the pretest ($\rho = 0.563$; bias: 4.29, 95% LoA: -36.32-27.74%) and the posttest ($\rho = 0.718$, bias: 0.69, 95% LoA: -39.37-40.77%). In conclusion, an unopposed repetition-based dynamic task detected reductions in lateral preference index after an eight-week nondominant training period. These results agreed with those observed with the opposed-bouts task. This indicates the eligibility of *yakusoku geiko* for coaching delivery due to general suitability of the unopposed repetition-based dynamic task to track the maintenance or progression of left-handedness in judo trainees.

Key words: Laterality, judo, motor learning, skills acquisition.

Introduction

In sports, functional dominance is referred to as the preferential use of a limb or a stance based on its dominant use in motor functions in a specific spatial situation (Grouios, 2004). In judo athletes, a high rate of left-handedness reveals a particular sort of functional dominance in comparison with the nonathlete population and noncombat sports (Grouios et al., 2000). This suggests a concrete strategic advantage for left preference that lies in what is called the "fighting hypothesis" (Raymond et al., 1996). This hypothesis stands from an evolutionary perspective regarding a frequency-dependent advantage, in which left-handers have a greater advantage during fights or aggressive interactions since they benefit from unfamiliarity in combat and can throw from unexpected directions and at different angles in comparison with right-handers. In this sense, a left staggered stance changes how the weight is usually loaded on the right leg and foot to stabilize the upper body, causing a deviation of the center of masses (Wang et al., 2012), and thus modifying the standing center of pressure (Muddle et al., 2017). Additionally, a left grip laterality and throwing side preference results in higher scores in comparison with the right side (Kajmovic and Radjo, 2014). This would force right-handers to reverse their usual strategies when facing left-handers (Grouios et al., 2000; Tirp et al., 2014). This hypothesis would not only justify the existence and persistence of left-handers in society but the higher predominance of left-handers in fighting sports in comparison with individuals not involved in sports or individuals involved in other sports (Grouios et al., 2000).

Nevertheless, recent studies indicate that the more prominent left lateral preference in judo athletes is shaped by experience (Dopico et al., 2014; Mikheev et al., 2002; Sterkowicz et al., 2010). On the one hand, during the initial stages of training, left-sided trainees receive right-handed instructions by their coaches, which are normally right-sided or choose right-side coaching to make the learning process more economical (Sterkowicz et al., 2010). On the other hand, it seems that motor profiles from rightness to leftness may evolve because of intensive, long-term training (Mikheev et al., 2002), due to the adaptive constraints caused by the performance environment (Tirp et al., 2014). As a matter of fact, lateral preference in judo is not associated with general lateral preference of daily life activities (Dopico et al., 2014), suggesting an adaptive process. Thus, the prevalence of left-preference fighting is more frequent among successful judo athletes and in high-level judo competitions since the technical or tactical demands of the competition may change so they develop strategies to overcome them (Mikheev et al., 2002; Tirp et al., 2014).

Thus, it is not clear whether the left lateral preference of the athlete predisposes him or her to excel in judo, or if participation in judo influences the motoric dominant pattern. Nevertheless, it is clear that transforming from right-handed to left-handed may have a strategic advantage that increases the chances of success in competition (Dopico et al., 2014). This permits the "construction of *judokas* based on functional dominance" (Dopico et al., 2014), as a means for benefiting from a frequency-dependent advantage (Grouios et al., 2000).

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A previous study has shown that after an eight-week period of nondominant practice (i.e., training judo exclusively on the nondominant leg, arm, and turn sides), a sample of right-handed novice practitioners reduced the percentage of actions executed as a right-handed performer (i.e., lateral preference index) from around 78% to 23% in a combat context (i.e., *randori*) (Iglesias-Soler et al., 2018). Otherwise, bilateral or control practitioners did not change the percentage of right-handed actions, always showing frequency values between 69-77% (Iglesias-Soler et al., 2018). Nevertheless, tasks used in that particular study were based on *randori* combats, thus being effort- and time-consuming for judo practitioners (Franchini et al., 2014). In this regard, tasks that are not only effective but also effort- and time-efficient are still needed in order to track the maintenance or progression of the lateral preference according to competition needs without enduring an excessive overload on the session.

In the present study, we expand these previous findings to an unopposed repetition-based dynamic task (*yakusoku geiko*), less demanding and less time-consuming than an opposed-bouts task (*randori)*. Our aim was to analyze the sensitivity of this task to detect the changes in lateral preference observed previously in the opposed-bouts task (Iglesias-Soler et al., 2018). Our inference is that the task proposed in this study is a valid and superior alternative since it is more convenient in terms of effort and time usage.

Methods

Participants

This study is part of a wider project, from which results have been partially published (Iglesias-Soler et al., 2018). In this regard, for a detailed description of how the random sampling was carried out, see Iglesias-Soler et al. (2018). Briefly, from an initial sample pool of 73 potential participants, a final sample of 30 new trainees participated in the study (22 men and 8 women). The participant inclusion criterion was demonstrated right-handedness, right-footedness, and turning in the counterclockwise direction following the procedures detailed below. The exclusion criterion was an absence of the aforementioned points or having previous experience practicing judo. Physical characteristics of the participants were 19 ± 1 years, 1.71 ± 0.07 m, and 65.8 ± 9.2 kg, for age, height, and body mass, respectively. Four participants withdrew from the study due to scheduling conflicts with the training sessions. Ethical clearance was obtained from the local Institutional Review Board and performed in accordance with the Declaration of Helsinki. All the participants signed an informed consent in which their rights as human research subjects were explained.

Experimental design

A randomized controlled trial was conducted in which participants were divided based on their gender and weight. Thus, the practice was designed such that there were 11 total subgroups in which every member of their group fought against the rest of the members of the same gender and weight. In this way, men were divided into eight subgroups, containing six groups of three men and two groups with two men. The women were divided into three subgroups, containing two groups of three women and one group with two women. Testing and practice were performed between September and December at approximately the same hour of the day.

Since the participants were novice judokas, they performed twelve orientation sessions in which they were familiarized bilaterally with techniques with turning before the technique and with actions without turning before the technique using one supporting leg prior to the testing and intervention sessions (Dopico et al., 2014).

Secondly, participants carried out two testing sessions, one before and one after the intervention training process. These testing sessions consisted of a pretest and a posttest in which they performed a *yakusoku geiko* and a *randori* task in successive trials and in this particular order in order to collect the lateral preference index on such exercises. The *yakusoku geiko* task consisted of one practicing bout of one minute. The *randori* task consisted of 2 fighting bouts of 3 minutes including pauses, with at least nine minutes of rest between fighting bouts. During both exercises, participants did not receive instructions about the lateral preference of the performed techniques and only throwing techniques (i.e., *nage-waza*) were allowed. After the pretest, every subgroup of participants was randomly assigned to either a control group, a bilateral group, or a nondominant group. This assignment resulted in a control group of 11 participants (eight men and three women), a bilateral group of eight participants (six men and two women), and a nondominant group of 11 participants (eight men and three women).

After assignment, the participants performed the intervention sessions during eight weeks at a frequency of three sessions per week, plus two practical judo subject sessions per week as a part of the sport science curricula. During these eight weeks of practice, participants of the control group did not receive any instruction about the side of practice while executing, while participants of the bilateral group performed the practice with both dominant and nondominant sides. Lastly, the nondominant group performed the practice with their nondominant side (i.e., left side). After 1-2 weeks of the intervention sessions, the posttest was carried out as previously explained.

Procedures

Motoric dominance for hands (Compared Handwriting and Ball Throw tests), legs (Ball Kick and Bach-heel Gesture tests), and turning (180º rotation without moving the feet from the standing position and jump and turn 360º from the standing position tests) were evaluated using specific tests to analyze the motoric dominance. These tests have been used to evaluate the motoric dominance in judo athletes and described in detail previously (Dopico et al., 2014; Iglesias-Soler et al., 2018).

The unopposed repetition-based dynamic task (*yakusoku geiko*) and the opposed-bouts task (*randori*) were recorded with a video camera (Sony, DCR-SX15, Tokyo, Japan) located approximately five meters from the judo mat. As was previously explained, the *yakusoku geiko* task consisted of a free practicing bout of one minute without instructions about the lateral preference of the techniques.

On the other hand, the *randori* task consisted of 2 fighting bouts of 3 minutes including pauses, with no less than nine minutes of rest between bouts, and also without instructions regarding the lateral preference of the executions. In both tasks, only throwing techniques were allowed. The video recording of both tasks was analyzed by one of the researchers (EI), in which both the ineffective and effective techniques were classified as right- or left-side depending on the criteria explained below.

All the techniques recorded and classified by every participant were analyzed for obtaining a lateral preference index in both tests that represented the percentage of actions executed as a right-handed performer. The lateral preference index is calculated using the following formula (Iglesias-Soler et al., 2018): Lateral preference index = [number of right actions / (number of right actions + number of left actions)] × 100. This was carried out before (pretest) and after (posttest) the intervention period. Right actions were classified following a classification previously published (Dopico et al., 2014), in which techniques were classified as right-sided if: (a) in techniques with turning before execution (e.g., *seoi nage, o goshi, uchi mata*), such techniques were performed while turning counterclockwise, (b) in techniques without turning before the action using one supporting leg (e.g., *o soto gari, ko uchi gari*), the supporting leg and the active leg were the right and left ones, respectively. Following previous criteria (Iglesias-Soler et al., 2018), for an action to be eligible as a valid action to calculate the lateral preference index, one criterion should have been fulfilled: (a) in techniques with turning before execution, the back of the performer should have contact with the trunk of the opponent before the start of the action; and (b) in techniques without turning before the action and one supporting leg, the active leg should have contact with at least one leg of the opponent before the start of the action. This methodology to qualify valid techniques has been previously observed to report high levels of reliability (Iglesias-Soler et al., 2018).

Intervention sessions

Training sessions included the aforementioned groups of techniques, that is, techniques with turning (e.g., *seoi nage, o goshi, uchi mata*) and without turning (e.g., *o soto gari, ko uchi gari*) before execution (Dopico et al., 2014). Every training session consisted of technical tasks and *randori* with a total duration of around 45 minutes and around 180 actions performed per session. The intensity of the training sessions was progressively increased by adding training volume (i.e., increasing the number of repetitions, the duration of the tasks, or both) and/or the coordinative and bioinformational complexity of the tasks. As was previously explained, the control group did not receive any instruction about the side of practice while executing. Otherwise, the bilateral group performed the practice with both dominant and nondominant sides in a fashion where the dominant side was used first, then the nondominant side, but consecutively on both sides throughout sets of repetitions or time. Lastly, the nondominant group exclusively performed with their nondominant side (i.e., left side). The participants did not engage in fighting bouts other than those included in the intervention sessions of the experiment.

Statistical analysis

Statistical analysis was performed using SPSS 20 (IBM, Armonk, NY, USA), nparLD R software package for the nonparametric ANOVA-type test (Noguchi et al., 2012), and GraphPad Prism software package for Windows (v5.03 GraphPad Prism Software Inc., San Diego, CA, USA) for the Bland-Altman analysis.

The Shapiro-Wilk test was used to analyze the normal distribution of lateral preference index during *yakusoku geiko* and *randori* tasks. Since normality distribution assumption was not recurrently satisfied, nonparametric ANOVA-style tests were implemented. The suitability of *yakusoku geiko* task for detecting reductions in the lateral preference index with the nondominant training, such as observed previously with *randori* task (Iglesias-Soler et al., 2018), was carried out with a 3 × 2 (practice [control, bilateral, and nondominant group] by time [pretest and posttest]) nonparametric ANOVA-type test. Concordance was conducted with a 2 × 2 (task [*yakusoku geiko* and *randori*] by time [pretest and posttest]) nonparametric ANOVA-type test. In addition, the Cohen's kappa coefficient (κ) was used to measure the agreement between tasks, treating the lateral preference index such as a categorical variable (i.e., a lateral preference index equal or higher than 50% meaning right-handedness and recoding such as 0, meanwhile a lateral preference index lower than 50% meaning left-handedness and recoding such as 1). Common strength of agreement values for κ are: poor = <.00, slight = .00-0.20, fair = .21-0.40, moderate = .41-0.60, substantial = .61-.80, and almost perfect = .81-0.99 (Viera and Garrett, 2005). Additionally, concordance was carried out with Spearman's rank correlation coefficient (ρ) and graphically analyzed by Bland-Altman plots, obtaining biases and 95% limits of agreement (LoA) (Nevill and Atkinson, 1997). Frequent absolute values of ρ regarding the concordance between measures are: weak = <.20, fair = .20-.40, and good = >.40-1.00 (Overholser and Sowinski, 2008). For *post hoc* comparisons, the Wilcoxon signed-rank test was used for paired comparisons while Mann–Whitney *U*-test with Bonferroni's adjustment was used for between groups comparisons. Effect sizes for between and within groups pairwise comparisons were calculated by the corresponding Rank Biserial Correlation (*r*) (Kerby, 2016). The results are summarized as means ± standard deviation unless otherwise indicated, and the significance level was set at .05.

Results

The data regarding the analysis of the lateral preference index during the *yakusoku geiko* task before and after the intervention training process can be observed in Table 1. The nonparametric ANOVA-type test for the lateral preference index during the yakusoku geiko task revealed a main effect for practice ($F_{1.71,\infty} = 10.81$, $p < 0.001$) and a significant interaction for practice by time ($F_{1.66,\infty} = 6.66$, $p = 0.003$). The main effect for practice revealed higher values in both the control group ($F_{1,\infty} = 17.1$, $p < 0.001$) and bilateral

group ($F_{1,\infty} = 17.03$, $p < 0.001$) in comparison with the nondominant group. The post hoc analysis of interaction for practice by time revealed a higher lateral preference index during the posttest for both the control group ($p < 0.001$; $r = 0.95$) and the bilateral group ($p < 0.001$; $r = 0.96$) in comparison with the nondominant group. The post hoc analysis of interaction for time by practice between the pretest and the posttest showed a significant reduction for the nondominant group ($p = 0.003$; $r = 1$). A main effect for time was not observed ($F_{1,\infty} = 2.68$, $p = 0.1$).

Table 1. Lateral preference index (%) using an unopposed repetition-based dynamic task (*yakusoku geiko*) for control group, bilateral group, and nondominant group before and after the intervention training process.

	Pretest	Posttest
Control group (n = 11)	76.1 ± 27.0	78.4 ± 17.1*†
Bilateral group (n = 8)	81.4 ± 11.7	73.1 ± 22.3*
Nondominant group (n = 11)	76.4 ± 15.9	16.6 ± 20.9†

*Significantly different versus nondominant group ($p < 0.05$).
†Significantly different versus pretest ($p < 0.05$).

The analysis of concordance of the lateral preference index between the unopposed repetition-based dynamic task (yakusoku geiko) and the opposed-bouts task (randori) task using the nonparametric ANOVA-type test revealed nonsignificant differences for the main effect of practice ($F_{1,\infty} = 2.99$, $p = 0.08$), the main effect of time ($F_{1,\infty} = 2.73$, $p = 0.1$), and the practice by time interaction ($F_{1,\infty} = 0.02$, $p = 0.9$). The agreement between the yakusoku geiko and the randori tasks for qualifying performers as left- or right-handers (i.e., lateral preference index lower, or equal or higher than 50%, respectively) was significant for both the pretest ($\kappa = 0.634$, $p < 0.001$; disagreement in two cases) and the posttest ($\kappa = 0.507$, $p = 0.005$; disagreement in seven cases). This points out a total disagreement of 9 cases out of 60. Spearman's rank correlation coefficient revealed that the lateral preference index between the yakusoku geiko and the randori tasks were significant for both the pretest ($\rho = 0.563$, $p = 0.001$) and the posttest ($\rho = 0.718$, $p = 0.001$). Bland-Altman plots comparing the yakusoku geiko and the randori tasks during the pretest (a) and the posttest (b) are reported in Figure 1. The biases were -4.29% (95% LoA: -36.32 to 27.74%) and 0.70% (95% LoA: -39.37 to 40.77%) for the pretest and posttest, respectively.

Discussion

The data arising from our study indicate that changes in the lateral preference index detected by an unopposed repetition-based dynamic task (*yakusoku geiko*) agree with those changes in lateral preference observed with an opposed-bouts task (*randori*). In this sense, no significant differences between tasks were detected, whereas significant agreements and correlations with low biases were obtained. This indicates general suitability of the *yakusoku geiko* task to track the maintenance or progression of the lateral preference in judo trainees.

The significant interaction observed between the three practices during the *yakusoku geiko* agree with those previously reported for the *randori* (Iglesias-Soler et al., 2018). In this regard, our results confirm that after eight weeks of training of nondominant side practice, trainees reduced the lateral preference index from right-handedness to left-handedness. Additionally, this occurred while the other groups with nonspecific practice (i.e., a control group without any instruction regarding the side of practice while executing) or bilateral practice (i.e., a group practicing with both dominant and nondominant sides) maintained the right-handedness. The use of an open environment task such as the *randori* should be understood as a gold standard since the real demands of an actual contest such as the competition (*shiai*) are imitated, thus having the greatest external validity possible (Franchini et al., 2011). Nevertheless, randori is physically demanding and time-consuming (Franchini et al., 2014), possibly enduring an excessive overload on the session (Degoutte et al., 2003).

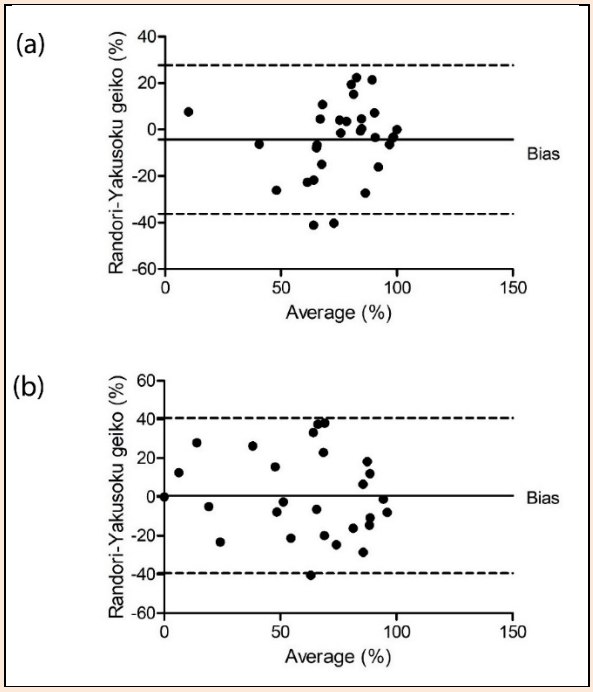

Figure 1. Bland-Altman plots showing the agreement between the lateral preference index obtained for the unopposed repetition-based dynamic task (*yakusoku geiko*) and the opposed-bouts task (*randori*) task during the pretest (a) and the posttest (b) (n = 30).

In comparison with open environment tasks, other tasks which are closed such as *yakusoku geiko* do not replicate the particular features of competition (Haaland and Hoff, 2003; Teixeira et al., 2003). Nevertheless, they might be effective and efficient if they are able to represent reasonably the same information compared to open environment tasks. This is the case of the current data since our test detected more extreme but comparable lateral preference index in both the changes from right-handedness to left-handedness in the nondominant group (*yakusoku geiko*: 76.4% to 16.6%; *randori*: 77.8% to 23.3%), and in the maintenance of right-handedness in the control and bilateral groups (*yakusoku geiko*: 81.4% to 73.1%; *randori*: 68.9% to 72.9%).

In this regard, concordance analyses showed general suitability of the *yakusoku geiko* to track the lateral preference in judo athletes when compared with *randori*.

Firstly, the interaction for practice by time of the nonparametric ANOVA-type test revealed that in both tasks values of lateral preference index before and after the different training processes were comparable. Secondly, significant agreements were observed with the Cohen's kappa coefficient, indicating that both tasks were able to detect the lateral preference in the same way. Thirdly, nonparametric correlation analysis showed significant correlations between the *yakusoku geiko* and the *randori* task lateral preference indices in both the pretest and the posttest, indicating an overall moderate-to-strong association between both evaluations. Fourthly and lastly, Bland-Altman analysis between tasks revealed low biases both before and after training. However, it must be stressed that relatively wide 95% LoA were obtained, which suggests differences between the lateral preference index obtained in both tasks for individual cases. Nevertheless, it must be mentioned that the lateral preference indices present disagreements in qualitative terms (i.e., right-handedness versus left-handedness) as a consequence of the κ analysis between tasks were only observed in 9 out of the 60 total comparisons. This suggests an overall capacity for detecting lateral preference maintenance or progression with the *yakusoku geiko*. Two questions arise from this study: on the one hand, it would be interesting to know if other tasks such as *uchi komi* or *nage komi* would help to track these changes in lateral preference. On the other hand, since an unopposed repetition-based dynamic task such as *yakusoku geiko* is able to track changes in lateral preference in novice judokas, doubt arises if this task would reflect the same properties and abilities to observe the transformation to left-handedness in experienced judokas. Further studies should determine these two issues. In summary the prevalence of left-preference, both the *yakusoku geiko* and the *randori* tasks represent the same construct, the former being an alternative valid test to track maintenance or progression of lateral preference in judo trainees. This *yakusoku geiko* task, therefore, would give precious information to the coaches in a less demanding test in terms of effort and time usage.

A potential limitation should be indicated. The implementation of a retention test could be appropriate sometime after the posttest since a lack, maintenance, or progression of lateral preference after some time might exist. In this sense, it would be interesting to analyze if both tests would be able to detect those changes in the same way after a clearance time.

Conclusion

Our results indicate that an unopposed task such as the *yakusoku geiko* is able to track left-handedness or the absence, maintenance, or progression into left-handedness in judo trainees. Additionally, the results of the *yakusoku geiko* agreed with those observed in an opposed task (*randori*), indicating eligibility for coaching delivery. In this sense, this study provides practical findings for coaches, who have now an effective and efficient test for analyzing the conversion of the judoka to left-handedness and potentially obtaining benefits from a frequency-dependent advantage.

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Key points

- An unopposed repetition-based dynamic task (*yakusoku geiko*-based test) is able to detect reductions in lateral preference index after 8 weeks of nondominant training sessions. In this sense, this test was able to track the progression into left-handedness or the maintenance of right-handedness depending on the analyzed group.
- This test was as good as a task based on opposed-bouts (*randori*), indicating an overall concordance in comparison with such an open environment task. Thus, *yakusoku geiko* is an alternative option as valid and effective as an open environment task to analyze the lateral preference of judo trainees.
- *Yakusoku* geiko provides the same information as the *randori* but in a less time-consuming manner under a closed environment while demands less physical effort from the trainee.

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