

Sports and the Lateralization of Lateral Spatial Neglect: A Comparative Study of Practitioners of Foot Orienteering, Judo Wrestlers and Non-Athletes

Ina Dimitrova

Department of Psychology, South-West University “Neofit Rilski”, Blagoevgrad (Bulgaria)
E-mail i.alex.dim@gmail.com

Abstract. Performance in all sports requires good spatial accuracy. This study investigates the impact of long-term sports training on the lateralization of visual spatial accuracy and also explores if the type of sport (foot orienteering (FootO) vs. judo) could be related to differentiated effects on the pattern of lateralization. Thirty practitioners of FootO (aged 16–58 years, Mean age = 24.96±10.98; 16 males), 30 judo wrestlers (aged 16–60 years, Mean age = 25.96±10.61; 19 males), and 30 subjects who have never practiced any sport (aged 15–53 years, Mean age = 33.2±11.56 13 males), were studied with a line-bisection task. All participants were right-handed, and the athletes had at least 5 years of active sport practicing. Although the mean transection in the three groups was to the left of the true center regardless of the hand used suggesting right pseudoneglect, the accuracy of both hands was highest in the group of practitioners of FootO and lowest in the non-athletes group. Also, there were no between-hands differences in the accuracy among practitioners of FootO ($t_{(30)} = 0.062, p = 0.951 > 0.05$), slightly better right hand accuracy in judo wrestlers ($t_{(30)} = 0.608, p = 0.548 > 0.05$), and significantly better right hand accuracy in non-athletes ($t_{(30)} = -2.297, p = 0.029 < 0.05$). In general, the results suggest that the active long-term training of any sport may affect functional brain organization of spatial accuracy towards its more balanced hemispheric presentation, but the type of sport is of great importance for the magnitude of the induced changes.

Keywords: lateralization, accuracy, foot orienteering, judo.

Sportavimas ir lateralinio erdvinio neigimo lateralizacija: orientavimosi pėsčiomis sportininkų, dziudo imtynininkų ir nesportuojančių asmenų palyginimas

Santrauka. Norint pasiekti gerų bet kurios sporto šakos rezultatų, reikia gero erdvinio tikslumo. Šiame tyrime analizuojamas ilgalaikių sporto treniruočių poveikis vizualinio erdvinio tikslumo lateralizacijai, taip pat nagrinėjama, ar sporto šaka (orientavimosi pėsčiomis (OP) ir dziudo) gali sietis su skirtingu lateralizacijos modeliu. Trisdešimt OP sportininkų (16–58 metų, vidutinis amžius – 24,96 ± 10,98; 16 vyrų), 30 dziudo imtynininkų (16–60 metų, vidutinis amžius 25,96 ± 10,61; 19 vyrų) ir 30 tyrimo dalyvių, kurie niekada nepraktikavo jokio sporto (15–53 metų, vidutinis amžius 33,2 ± 11,56; 13 vyrų), atliko linijos dalijimo užduotį. Visi tyrimo dalyviai buvo dešiniarankiai, sportininkai turėjo bent penkerių metų patirtį. Linijos dalijimo užduoties vidurkis buvo pasislinkęs į kairę nuo tikro centro visose trijose grupėse, tačiau abiejų rankų tikslumas buvo didžiausias OP, o mažiausias nesportuojančiųjų grupėje. Tikslumo skirtumo, dalijant liniją skirtinga ranka, nerasta OP sportininkų grupėje ($t_{(30)} = 0,062, p = 0,951$), atlikimas, naudojant dešinę ranką, buvo nereikšmingai geresnis dziudo sportininkų grupėje ($t_{(30)} = 0,608, p = 0,548$), o nesportuojančiųjų grupėje rastas statistiškai reikšmingai geresnis tikslumas, naudojant dešinę ranką ($t_{(30)} = -2,297, p = 0,029$). Rezultatai

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leidžia teigti, kad bet kurio sporto praktikavimas gali veikti vizualinio tikslumo organizaciją smegenyse, skatinti geresnį balansą tarp pusrutulių, tačiau sporto šaka nėra ypač svarbi pokyčių dydžiui.

Pagrindiniai žodžiai: lateralizacija, tikslumas, orientavimasis pėsčiomis, dziudo.

1. Introduction

Through the mechanisms of neural plasticity, the hemispheric lateralization of the brain is not a static phenomenon but is related to dynamic changes throughout the lifespan. This happens through different genetic and environmental factors (Asenova, 2018; Bishop, 2013). It is well documented that during adulthood the lateralization undergoes changes related to its reduction (Cabeza, 2002). Apart from age-related changes, data shows that functional asymmetries change also through a long-term and purposeful training of the cognitive activities. Studies of subjects with different occupations have evidenced obvious differences in the pattern of functional asymmetries (motor, sensory or cognitive) between professional musicians and non-musicians (Messerli, Pegna, & Sordet, 1995; Spajdel, Jariabkova, & Rieicansky, 2007), musicians and painters (Hassler, 1990), highly qualified judo wrestlers and beginners (Mikeev et al., 2002), subjects with high ability in mathematics and subjects with high ability of pictorial art (Asenova, 2011a), proficient bi- and multilinguals and monolinguals (Asenova, 2011b).

Provoked by the assumption that long-term sports training of foot orienteering (FootO), as a specific sport requiring not only good physical preparation but also very well-developed spatial orientation skills, could lead to changes in hemispheric asymmetries for spatial accuracy through the mechanisms of neural plasticity, we conducted recently a comparative study using line-bisection task between subjects who have actively practiced Foot orienteering and subjects who have never practiced any sport (Asenova & Dimitrova, 2019). The hand bisection of horizontal lines is a frequently used test to study lateralization of spatial accuracy. Usually, when performing this task, neurologically intact adults tend to bisect slightly to left of true center with both hands (Hausmann et al., 2002). This systematic error has been called right pseudoneglect (Bowers & Heilman, 1980) and supposedly reflects the right hemisphere dominance for spatial accuracy (Hausmann et al., 2002; Jewell & McCourt, 2000). Although both groups in this study demonstrated the typical right pseudoneglect, the group of FootO practitioners showed greater accuracy and smaller intermanual difference suggesting more balanced spatial accuracy in FootO practitioners than in non-athletes.

These findings brought the idea of the present study with the main purpose to compare the effects of long-term training in FootO versus long-term judo training on the lateralization of spatial accuracy, although both sports are related to complex activities requiring close cooperation and effective communication between right and left cerebral hemispheres. For this reason it was hypothesized that long-term training of both sports would have effects on functional asymmetries for spatial accuracy, but the long-term training in FootO would be associated with a greater effect, due to the special training of visual-spatial orientation skills.

2. Method

2.1. Subjects

Thirty right-handed subjects who have actively practiced FootO for at least five years (aged 16–58 years, Mean age = $24,96 \pm 10,98$; 16 males), thirty right-handed subjects who have actively practiced judo for at least five years (aged 16–60 years, Mean age = $25,96 \pm 10,61$; 19 males) and 30 right-handed subjects who have never practiced any sport (aged 15–53 years, Mean age = $33,2 \pm 11,56$ 13 males), voluntarily participated in the present study.

2.2. Assessment of handedness

Handedness of the participants was examined by the Edinburgh Handedness Inventory (Oldfield, 1971). A Quotient of manual asymmetry (Q_{ma}) was calculated individually for each participant. All participants in the present study had Q_{ma} between +71 and +100, i.e. were classified as right-handed. These cut off points have been established by Dragovic (2004) depending on statistical criteria.

2.3. Line bisection task

The used line-bisection task (Hausmann et al., 2002) consisted of one page with 17 horizontal lines, ranging from 100 to 260 mm in length and separated by a 10-mm gap. Lines were randomly placed on the sheet, with 5 to the right, 5 to the left and 7 in the center.

Participants were instructed to bisect each line into two equal parts (with a pencil), starting from the top of the page, covering previously bisected lines. Each participant performed the task twice, once with each hand.

Deviation from each line's true centre was measured to 0.5 mm accuracy. These values were subtracted from the half of the length of related lines to obtain bisection errors. For each subject, the mean bisection errors were calculated separately for left hand performance and right hand performance. The leftward errors were scored as negative numbers and the rightward errors were scored as positive numbers.

3. Results

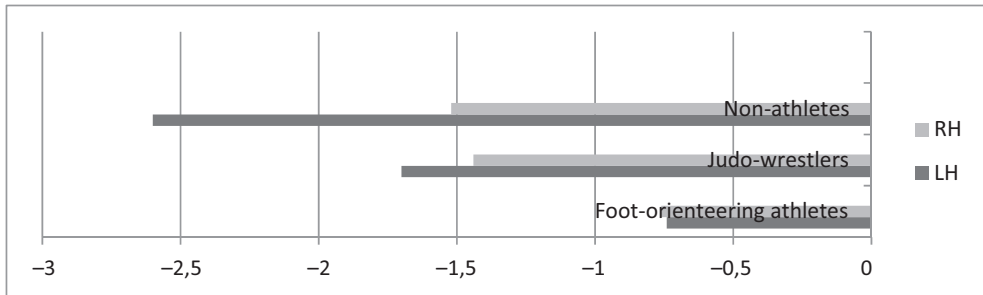
According to the Descriptive statistics, the three groups bisected left of the true centre with the left hand (FootO practitioners $Mean = -0.74$, $SD = 1.12$; judo wrestlers $Mean = -1.70$, $SD = 2.52$; non-athletes $Mean = -2.6$, $SD = 3.69$) as well as with the right hand (FootO practitioners $Mean = -0.76$, $SD = 1.43$; judo wrestlers $Mean = -1.44$, $SD = 2.14$; non-athletes $Mean = -1.52$, $SD = 2.84$). Therefore, the three groups displayed the typically observed in healthy adults right pseudoneglect (see Table 1 and Graphic 1).

According to the ANOVA analysis there are statistically significant between-group differences in mean deviation scores for the left hand ($F(2) = 3.684$; $p = 0.029 < 0.05$), but no significant differences in mean Deviation scores for the right hand ($F(2) = 1.08$; $p = 0.344 > 0.05$). Post hoc Analysis of Tukey indicated statistically significant differences

in the mean deviation scores for the left hand between the group of practitioners of FootO and non-athletes ($p = 0.022 < 0.05$).

Table 1. Mean deviation scores (M; SD) for left hand (MDElh) and right hand (MDErh) of studied groups

	N	MDElh (SD)	MDErh (SD)	t (p)
FootOathletes	30	-0.74 (1.12)	-0.76 (1.43)	$t_{(30)} = 0.062; p = 0.951$
Judo-wrestlers	30	-1.70 (2.52)	-1.44 (2.14)	$t_{(30)} = 0.608; p = 0.548$
Non-athletes	30	-2.6 (3.69)	-1.52 (2.84)	$t_{(30)} = -2.297; p = 0.029$



Graphic 1. Mean deviation on line bisection task for left hand (LH) and right hand (RH) of studied groups

Chi-square analysis was performed to compare the frequency of right pseudoneglect in the three studied groups. The results did not find significant between-group differences in the percentages of participants who showed right pseudoneglect: 60% of the FootO athletes, 63% of the judo wrestlers and 66% of the non-athletes demonstrated this pattern of line-bisection performance ($\chi^2_{|3|} = 7.387, p = 0.287$; Cramer's $V = 0.203$).

Finally, the within-group comparison of the task performance as a function of the hand used, found that there was no difference between the bias with the left hand and the bias with the right hand for the group of practitioners of FootO ($t_{(30)} = 0.062, p = 0.951 > 0.05$), there was slightly more pronounced bias to the left with the left hand than with the right hand for the judo wrestlers ($t_{(30)} = 0.608, p = 0.548 > 0.05$), and more pronounced bias to the left than to the right only for the group of non-athletes ($t_{(30)} = -2.297, p = 0.029 < 0.05$). Therefore, the findings indicate the significant effect of the hand used only in the group of non-athletes.

4. Discussion

The results from this study support the hypothesis that long-term practice of different sports might induce changes in the functional lateralization of spatial accuracy, but the magnitude of the induced changes will depend on the type of sport and its specifics.

The obtained results revealed that the mean transection in the three groups was to the left of the true centre regardless of the hand used, suggesting right pseudoneglect. This finding is consistent with a previous relevant study (see introduction) confirming the existence of a tendency for left bias of the line-bisection (right pseudoneglect) in neurologically intact adults. The accuracy of both hands, however, was highest in the group of practitioners of FootO and lowest in the non-athletes group. Also, there were no between-hands differences in the accuracy among practitioners of FootO, slightly better right hand accuracy in judo wrestlers, and significantly better right hand accuracy in non-athletes.

Therefore, according to the new findings of the present study, practitioners of FootO bisected the lines more accurately than the group of judo-wrestlers and non-athletes, and the effect of the hand (greater leftward bias in use of the left rather than the right hand), typically observed in general population (for a review see Jewell & McCourt, 2000), was missing in the group of FootO and judo-wrestlers, but was present in the non-athletes group.

These findings confirmed the hypothesis that different kinds of sports in which visual spacial perception is trained long-term could induce changes on the functional assymetries for spatial accuracy throughout the mechanisms of neuroplasticity in relation to spatial accuracy in the direction of its reduction. The findings of the present study indicated that practitioners of FootO as well as judo wrestlers perform better tasks related to visual-spatial attention comparative to the group of non-practitioners. There is a tendency that the group of FootO makes the best performance on visual-spatial tasks, followed by judo-wrestlers and on the third place – non-athletes. It is supposed that the most accurate performance and the smaller error when bisecting with both hands which is observed among the practitioners of FootO compared to judo-wrestlers and non-athletes, could be due to the fact that FootO is related to continuous training of the left-right hemispheric orientation and the co-operation of both hemispheres. Orienteering using a map is typically a left-hemispheric function and real orienteering on the terrain – a right-hemispheric function. This could make the lateralization of spatial accuracy more balanced.

The limitations of the study come of the relatively small number of participants. In future that amount of participants will be increased, also the variety of it.

5. Conclusion

The present study results assure new evidence of the suggestion that the active long-term training of any sport may affect functional brain organization of the control of spatial accuracy towards its more balanced hemispheric presentation, but the type of sport is of great importance for the magnitude of the induced changes. Despite the small number of participants in this study, we suggest that our future research will prove that foot orienteering might have positive impact on parameters of spatial accuracy.

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