REVIJA ZA ELEMENTARNO IZOBRAŽEVANJE
JOURNAL OF ELEMENTARY EDUCATION
Vol. 15, No. 3, pp. 285–299, September 2022

INTEGRATION OF BILATERAL COORDINATION IN CHILDREN'S MOTOR LEARNING PROCESS

SANJA LJUBIČIĆ[1], LJUBOMIR ANTEKOLOVIĆ[2] & VILKO PETRIĆ[1]

Potrjeno/Accepted
1. 12. 2021

Objavljeno/Published
23. 9. 2022

[1] University of Rijeka, Faculty of Teacher Education, Rijeka, Croatia
[2] University of Zagreb, Faculty of Kinesiology, Zagreb, Croatia

CORRESPONDING AUTHOR/KORESPONDENČNI AVTOR
sanja.ljubicic@uniri.hr

Abstract/Izvleček The purpose of this research was to establish the differences in the bilateral and unilateral exercising effects on high jump performance using the scissors technique, with take-off from the dominant leg. As many as 74 participants aged 7 to 12, who were randomly chosen and divided into two experimental groups, took part in the study. The experimental groups had training twice a week for twelve weeks. Measurements were conducted at three points in time, and the results showed that the bilateral training intervention produced symmetrical effects equal to those from unilateral interventions of exclusively the dominant leg, which finding is extremely important for symmetrical muscular and locomotor development, as well as for a practical approach to children.

Keywords:
high jump, scissors technique, bilateral exercising, unilateral exercising, dominant leg

Vključevanje dvostranskega usklajevanja pri otrocih Proces motoričnega učenja
Namen raziskave je bil ugotoviti razlike v učinkih bilateralne in unilateralne vaje pri izvajanju skoka v višino s prekoračno tehniko odriva z dominantno nogo. Sodelovalo je 74 vprašancev v starosti od 7-12 let, ki so bili po naključni izbiri razdeljeni v dve eksperimentalni skupini. Eksepimentalne skupine so trenirale 12 tednov po 2 krat na teden. Meritve so bile izvedene v treh časovnih točkah. Rezultati so pokazali, da z bilateralno trenažno intervencijo dosežemo simetrične učinke kot pri unilateralni intervenciji izključno z dominantno nogo, kar je izredno pomembno za simetričen mišični in lokomotorni razvoj, in s tem tudi za praktičen pristop otrokom.

Ključne besede:
skok v višino, prekoračna tehnika, bilateralna vaja, unilateralna vaja, dominantna noga

UDK/UDC
796.431.1:796.012.1

DOI https://doi.org/10.18690/rei.15.3.285-299.2022

University of Maribor Press

Introduction

The concept of motor learning or exercising relates to the process of motor skill formation, which can be defined as the ability to perform a certain motor task smoothly and harmoniously. Although motor learning can be considered independently from other types of learning and problem solving, if formally analysed, on the conceptual level it belongs to the category of equal cognitive processes - learning processes (Horga, 1993). Exercising develops a "motor programme," while literature offers terms such as "algorithm of orders" or "formation of dynamic stereotypes," containing data on the structure, order and duration of movement performance and enabling information processing during the performance of the task. Barić (2006) states that the learning process and motor skill training occur gradually and are achieved by repetition, while the level of conscious control of motor action and the necessary concentration for the performance decreesed over time. From early childhood, movement represents happiness and a challenge for children, so the acquisition of new and different motor actions, stored as motor skills, can be expected (Petrić, Kostadin and Peić, 2018). The concept of integrated learning is to a large extent seen as a theory in the approach to teaching children, and it is based on creating opportunities for exploring assumptions and satisfying curiosity through the interaction of the physical and social environment, as well as cooperation with peers and adults who can extend children's learning (Vujičić, Peić, Petrić, 2020). This article will direct attention to bilateral integration, which is defined as a neurological function important for the development of bilateral coordination and conduct skill (Fazlioglu and Gunsen, 2011). Williams (1983) defined bilateral coordination as the ability to use both sides of the body in an integrated and skilful act of management. In such a process, children learn to use both sides of the body in a symmetrical manner. The development of bilateral motor coordination begins in early childhood and provides the basis for future motor development (Berk and DeGangi, 1983). Learning motor skills is connected to deep changes in the patterns of brain activation over time (Coynel et al., 2010). Motor skills that are learned and practiced are often conducted unilaterally, i.e., with the dominant side of the body, from an early age. A high number of repetitions of a certain activity with only one part of the body can lead to lateral asymmetry, which has been confirmed by numerous studies conducted in diverse sports where the dominant extremity is usually overdeveloped (Castanharo et al., 2011; Cuckova and Suss, 2014). Consequently, this can lead to specialisation occurring too early. Situation-specific actions not only with the dominant, but also the non-dominant side of the body are extremely important in sports such as basketball, football, handball, or volleyball (Grouis, Kiodou, Tsorbatzoudis and Alexandris, 2002). Sinclair et al. (2014) indicate that training programmes should concentrate on exercises that include activities for both the dominant and non-dominant leg in order to correct any asymmetry and increase performance of repetitive, unilateral actions during competitions.

It seems that intelligence on both sides of the body may have significant benefits in sport. The transfer of knowledge caused by bilateral exercising may prevent an increase in lateral asymmetry, which is extremely important for sports games where the difference between the dominant and non-dominant side can be diminished to achieve an advantage in key moments. According to previous research, exercising the non-dominant side of the body can even improve the performance of the dominant side. If bilateral training intervention can lead to symmetrical effects as with unilateral intervention on the dominant leg alone, it can be of extreme importance for symmetrical muscular and locomotor development, and thus for the practical approach to exercising with children. Moreover, a better ratio between the load of the left and right sides of the body can diminish muscular imbalance and have a preventive effect against any increase in the occurrence of chronic diseases due to overloading the dominant side of the body. Additionally, the development of motor abilities would be enabled, for instance spatial coordination, symmetrical development of stamina, strength, and dynamic balance, while the use of both sides of the body is important for learning new and more complex motor movements.

Therefore, the basic aim of this research is to establish the difference between bilateral and unilateral exercise effects on high jump performance using the scissors technique with take-off from the dominant leg.

Methods

Sample of participants

There were 74 participants in this study (F = 43 and M = 31), aged 7 to 12. The participants were members of the Kvarner Athletics Club of Rijeka. Their parents signed consent for their children's participation in the research.

The research was approved by the Ethics Committee of the Faculty of Kinesiology at the University of Zagreb and by the Kvarner Athletics Club of Rijeka.
The criterion for the exclusion of some participants from the sample was his or her participation in less than 80% of the total number of training sessions, as well as any form of sports injury or disease. The assessment of the sample size was conducted with the help of the G*Power program and amounted to a minimum of 44 participants. The participants were randomly assigned to one of the two experimental groups: Experimental Group 1 (EG1), whose members had training using both the dominant and the non-dominant leg, and Experimental Group 2 (EG2), whose members used only the dominant leg (the take-off leg) in their training.

Sample of variables
The observed variables relate to jump height (REZ_VIS) and the duration of the take-off (T_ODRAZ_VIS) during the performance of the high jump using the scissors technique. The high jump height was annotated based on the height of the bar that was cleared, while the exact value of the height was measured by the mobile metre at its centre. The high jumps were recorded with a Sony RX10 II camera (high speed 250 pictures per second), whereas the 2D kinematic analysis was performed in the Kinovea 0.8.15 program. The photographic image in which the foot made the first contact with the ground was marked as the beginning of the take-off, while the picture taken before leaving the ground was marked as the last one. Based on the parameters set, the programme calculated the duration of the take-off in milliseconds.

Measurement protocol
Measurements were conducted at three points in time: at the beginning (before the beginning of the training protocol – *initial testing*), immediately after the training protocol (*final testing 1*), and three weeks after completion of the training protocol (*final testing 2*). Before beginning the measurements, the participants were informed about the testing protocol and had a standardised dynamic warm-up lasting 15 minutes. After the warm-up, we measured the high jump using the scissors technique with take-off from the dominant leg.

High jump using the scissors technique with take-off from the dominant leg

The criterion for a successful jump was that the participant cleared the bar without knocking it down, having performed a single-foot take-off.

If a participant performed a two-foot take-off, or did the jump with the leg opposite the run-up side, he or she was entitled to repeat the jump. The highest jump was recorded, while participants had three tries at all heights. When participants had either knocked the bar down three times or given up, the measuring was over. Participants were allowed to run up to the bar from a distance of 5 to 10 metres in order to avoid the negative effect of on jump height of a too long or too short runup on the jump height. The runway was marked with run-up markers to give participants equal conditions and rule out potential variations in approach to the bar, i.e., a landing mat.

Training protocol

The experimental groups trained for 12 weeks, twice a week, where the two training sessions had a pause in between of at least 48 hours. Before each performance of specific high jump exercises (SHJE), the standardised 10-minute warm-up procedure was conducted. The volume-load of the SHJE was determined based on the number of contacts of the foot with the ground (number of series x number of repetitions), and it went from 78 contacts in the initial phase to 102 contacts in the final phase of the training protocol. The SHJE consisted of nine types of jumps (Table 1). The distribution of the volume-load followed the continuity, progression, and undulation principles. Members of the EG2 performed the jumps exclusively with the dominant leg in all training phases, whereas the distribution of jumps with the dominant and non-dominant leg changed in EG1 over time in favour of the dominant leg.

Table 1. Specific high jump exercises

No.	Exercise name	Abbreviation
1.	Single-leg frontal jumps over the markers	JPK
2.	Single-leg jumps – frontal + lateral	JFL
3.	Every second step take-off over the hurdle	S2
4.	Grab jump	DS
5.	Jump with a straight run-up on a platform	RZT
6.	Jumping on a mat, curved run-up, scissors technique, from platform	SPP
7.	High jump, scissors technique	SPT
8.	Every second step take-off over the hurdle with scissors technique	DŠ
9.	Every fourth step take-off over the hurdle	S4

Table 2. Volume-load in the 12-week training period

Number of weeks	Specific high jumps	Total number of contacts	EG_1 25%, 50%, 75% non-dominant leg
1	JPK (48), JFL (24), DS (6)	78	20
2	JPL (30), JFL (30), S2 (18), DS (6)	84	21
3	JFL (48), S2 (32), DS (4), RZT (6)	90	23
4	JPK (30), JFL (30), S2 (18), RZT (6)	84	21
5	JFL (48), S2 (12), S4 (24)	84	42
6	JFL (48), S2 (32), RZT (6), SPT (6)	92	46
7	JPK (48), S4 (32), RZT (8), SPP (8)	96	48
8	JFL (44), S2 (24), DŠ (24)	92	46
9	JFL (48), JPK (36), SPT (8)	92	69
10	JFL (30), JPK (30), DŠ (30), SPP (6)	96	72
11	JPK (48), S4 (24), S2 (24), SPT (6)	102	76
12	JPK (33), JFL (33), DŠ (24), DS (6)	96	72

Statistical data analysis

The IBM SPSS 25 software package was used for statistical analysis. The arithmetic mean (M) and standard deviation (SD) were calculated for all variables and in all measurements. For all the variables of the initial and final measurements 1 and 2, the normality of variable distribution was tested by the Kolmogorov-Smirnov test (K-S).

To determine the difference in the average results between the initial and final measurement, the T-test for dependent variables was applied, while significance was additionally examined by the non-parametric test (Wilcox test of equivalent pairs).

To examine the difference in the results obtained from three measurements with regard to the experimental group (EG), two-factor analysis of the variance (group x time) with repeated measurements of one factor (time) was conducted on all the observed variables. If a significant F-ratio for the factor measurement time was determined, the multiple comparisons test (post-hoc test) was applied using the Bonferroni correction.

Cohen's d was calculated for each experimental group to gain insight into the amplitude of the effects in the calculation of differences in results between the initial and final measurement.

Results

Diagram 1 shows the distribution of high jump results by experimental group at all three points in time. The EG1 result of the initial measurement is 88.56 cm ± 15.92 (mean ± SD), the result of the final measurement_1 is 94.49 ± 15.69 (mean ± SD), and the result of the final measurement_2 is 93.32 cm ± 14.40 (mean ± SD). More precisely, in the final measurement_1 the improvement was 6.70%, and in the final measurement_2 it was 5.37% compared to the initial measurement. The EG2 result of the initial measurement is 88.67 cm ± 14.64 (mean ± SD), the result of the final measurement_1 is 94.27 cm ± 12.73 (mean ± SD), and the result of the final measurement_2 is 94.27 cm ± 12.05 (mean ± SD). Both final measurement_1 and final measurement_2 showed an improvement of 6.32% compared to the initial measurement. The standard deviation for both variables shows a high dispersion of results, but a slight decrease in the final measurement values can be observed. High dispersion can indicate a different level of motor knowledge and motor skills acquisition.

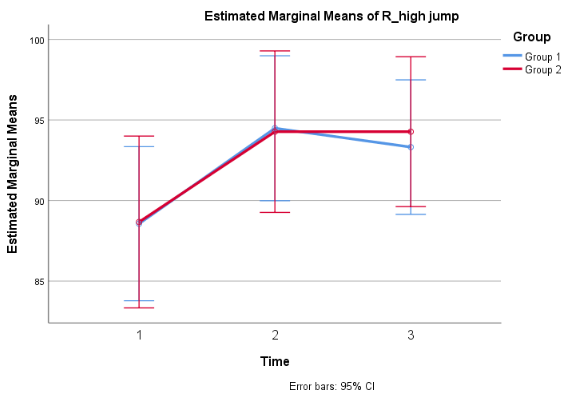

Diagram 1. Experimental groups' high jump results at three points in time

Diagram 2 shows the distribution of take-off duration results by experimental groups at all three points in time. The EG1 result of the initial measurement is 220.90 ms ± 32.39 (mean ± SD), the result of the final measurement_1 is 214.54 ms ± 26.38 (mean ± SD), and the result of the final measurement_2 is 212.88 ms ± 27.49 (mean ± SD). More precisely, in the final measurement_1 the improvement was 2.56%, and in the final measurement_2 it was 3.63% compared to the initial measurement.

The EG2 result of the initial measurement is 219.88 ms ± 26.87 (mean ± SD), the result of the final measurement_1 is 214.42 ms ± 25.24 (mean ± SD), and the result of the final measurement_2 is 214.91 ms ± 27.21 (mean ± SD). In the final measurement_1 the improvement was 2.48%, and final measurement_2 showed an improvement of 2.26% compared to the initial measurement. Higher standard deviation values indicate a high dispersion of results.

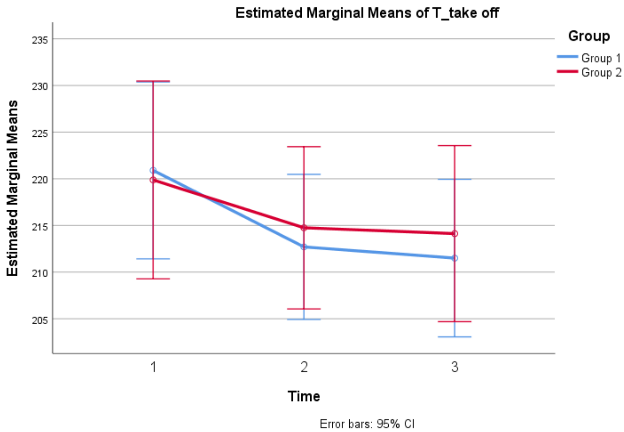

Diagram 2. *Duration of the take-off for experimental group participants at three points in time*

The dependent sample T-test was used to examine the differences in the average results for the jumping variables between the initial and final measurement, for each experimental group. EG1 achieved a statistically much higher result for the variable REZ_VIS in the final measurement than in the initial measurement ($t_{(40)}=8.58$, $p<.01$, $d=1.34$). No statistically significant difference was obtained between results in the initial and final measurement for EG2 for the variable T_ODRAZ_VIS ($t(39)=1.77$, $p>.05$).

Table 3. Average results of the jump variables in the initial and final measurement for EG1 – t-test results

	M	SD	t	df	p	Cohen's d
REZ_VIS - 1.	88.56	15.92	8.58**	40	0.000	1.34
REZ_VIS - 2.	94.49	15.69				
T_ODRAZ_VIS - 1.	220.90	32.39	1.77	39	0.085	0.28
T_ODRAZ_VIS - 2.	212.70	23.91				

**p<.01

Legend: M – arithmetic mean, SD – standard deviation, t – t-ratio, df – degrees of freedom, p – significance level, Cohen's d – effect size

The significance of the differences in results of the variable T_ODRAZ_VIS between the initial and final measurement for the EG1 was tested with the Wilcox test. The results are in line with the t-test results for independent variables, i.e., no statistically significant differences were obtained (Z=-1.29, p>.05).

Table 4. Wilcox test

	C	Q3-1	Z	p
T_ODRAZ_VIS - 1.	220.00	46.00	-1.29	0.197
T_ODRAZ_VIS - 2.	208.00	26.00		

Legend: C- median (central value), Q3-1- interquartile range, Z- value, p- significance level, T_ODRAZ_VIS – 1- duration of contact between the foot and the ground at the first measurement, T_ODRAZ_VIS – 2- duration of contact between the foot and the ground at the second measurement

Statistically speaking, the EG2 achieved a significantly better result for REZ_VIS in the final measurement than in the initial one (t(32)=5.68, p<.01, d=.99). No statistically significant difference was obtained between results of the T_ODRAZ_VIS variable at the initial and final measurement for group EG2 (t(31)=1.34, p>.05).

Table 5. Average results of the jump variables in the initial and final measurement for EG2 – t-test results

	M	SD	t	df	p	Cohen's d
REZ_VIS - 1.	88.67	14.64	5.68**	32	0.000	0.99
REZ_VIS - 2.	94.27	12.73				
T_ODRAZ_VIS - 1.	219.88	26.87	1.34	31	0.191	0.24
T_ODRAZ_VIS - 2.	214.75	25.57				

**p<.01

Legend: M – arithmetic mean, SD – standard deviation, t – t-ratio, df – degrees of freedom, p – significance level, Cohen's d – effect size

Two-way analysis of variance in high jump repeated measurements

The high jump results (REZ_VIS) indicate a significant F-ratio for the factor measurement time ($F(1.82,130.74)=52.48$, $p<.01$, $\eta p^2=.42$). The multiple comparisons (Bonferroni) indicate a significantly lower average result for the REZ_VIS in the first measurement (M=88.61, SE=1.80) than in the second (M=94.38, SE=1.69) and the third (M=93.79, SE=1.57), between which there is no significant difference.

A significant interaction between measurement time and experimental group was not obtained for the result of the variable REZ_VIS ($F(1.82,130.74)=0.48$, $p>.05$). A significant effect of the experimental group ($F(1, 72)=0.01$, $p>.05$) on the REZ_VIS variable result was not obtained.

Table 6. Results of the REZ_VIS variable at three measurements with regard to the experimental group – repeated measures ANOVA for the factor time

	SS	df	MS	F	p	η_p^2
Time	1473.38	1.82	811.42	52.48**	0.00	0.42
Time × EG	13.38	1.82	7.37	0.48	0.60	0.01
Error (Time)	2021.30	130.74	15.46			

**p<.01

Legend: SS-sum of squares, df-degrees of freedom, MS-mean square, F-value, p-significance level, ηp2 – effect size (partial η2)

A significant effect of measurement time on T_ODRAZ_VIS was obtained ($F(1.46,102.11)=4.07$, $p<.05$, $\eta_p^2=.05$). The Bonferroni post-hoc test results were not significant.

Table 7. Results of the T_ODRAZ_VIS variable at three measurements with regard to the experimental group – repeated measures ANOVA for the factor time

	SS	df	MS	F	p	η_p^2
Time	2432.05	1.46	1667.26	4.07*	0.03	0.05
Time × EG	136.94	1.46	93.88	0.23	0.72	0.00
Error (Time)	41813.13	102.11	409.49			

*p<.05

Legend: SS-sum of squares, df-degrees of freedom, MS-mean square, F-value, p-significance level, ηp2 – effect size (partial η2)

Discussion

The main aim of this study was linked to the nervous-muscular effects on the high jump performance of children and young athletes using the scissors technique with take-off from the dominant leg resulting from a change in various training treatments. As many as 74 children aged 7 to 12 participated in the study, and they were divided into two experimental groups. The first experimental group (EG1) had a training protocol where both dominant and non-dominant leg exercises were performed, whereas members of the second group (EG2) performed only with their dominant leg. The research results suggest that this is a question of a complex combination in the advancement of technique and improvement of average results in kinetic parameters. Both groups achieved significant improvement in their high jump results and average improvement in take-off speed, but a significant interaction of the experimental group and the result was not established.

According to available research on the effects of bilateral integration in a unilateral discipline among athletics jumping disciplines, Focke, Spancken, Stockingen, Thürer and Stein (2016) obtained results confirming that members of the bilateral group had significantly improved their long jump performance with the dominant leg (final measurement: 5.2%, retention: 7.4%), compared to those in the unilateral group (final measurement: 3.4%, retention: 4.5%). They explained these results with the theoretical models of the "bilateral approach" and "cross activation," but without clear guidelines to explain how those models contributed to the results. They suggested including both sides of the body in unilateral activities for young athletes. The results for the group that practised the task with both sides of the body are similar to the findings of this study, where significant improvement was also achieved (EG1 – final measurement_1: 6.70%, final measurement_2: 5.37%). Haaland and Hoff (2003) estimated the effects of bilateral motor performance after non-dominant leg training for experienced football players (aged 15 to 20). They concluded that non-dominant leg training had led to general improvement in the performance of skills on both sides of the body, even among experienced football players. The results were explained through general improvement of motor programmes or through the Dynamic Systems Approach, which indicates that the actual training is linked to the application of all information available to the subject in a given situation and that the body self-organises motor performances. Teixeira, Silva and Carvalho (2003) studied the effect of bilateral exercising in modification of lateral asymmetry in the motor skills area among football players aged 12 to 14.

The results showed that lateral asymmetry was reduced in the dribbling speed test among members of the group who trained with an emphasis on the dominant leg, while in the measurement of shoot force and precision, asymmetry remained constant, i.e., unchanged for both groups. Marinsek (2016) conducted research seeking to determine how various types of training (with the dominant limb, the non-dominant limb and both extremities) influenced the diminution of lateral asymmetry among preschool children. Results showed that unilateral exercising was better for the diminution of lateral asymmetry than bilateral exercising.

Correlating this finding with our research results, it can be concluded that unilateral exercising of both sides of the body yields results diminishing lateral asymmetry, and supposedly the symmetrical development of the motor abilities that underpin high jump performance, such as coordination, explosive power and dynamic balance of the lower extremities. Besides, the results of the present research are linked to a higher level of technical performance of the motor task, primarily because the training process was continually repeated.

The take-off phase is defined as the period between the first contact of the foot (the take-off leg) with the ground and the moment when the foot of the take-off leg leaves the ground (Čoh and Supej, 2008; Dapena, 1988), aiming at a maximally fast and explosive performance. Research studies state that the take-off is the most important phase as a factor in high jump success (Jacoby and Fraley, 1995; Dapena, 1988), and that the duration of the take-off is positively correlated with the height of the jump (Blažević, Antelković, and Mejovšek, 2006). During the take-off, horizontal speed transforms into vertical speed, thus determining the success of the jump (Dapena, 2006). Although the results achieved by both experimental groups do not indicate significant changes, the average duration of the take-off did improve (by becoming shorter). Kovács et al. (1999), as well as Pittinger, McCaw and Thomas (2002) conducted research into the effects of the diverse ways the foot is set on the ground in preparation for the take-off and the sole contact with the ground. Kovács et al. (1999) found that, regardless of which part of the foot first touched the ground (the front or rear part), there was similar muscular activation: gluteus, vastus lateralis, plantar flexor, except in cases of pre-activation when, if the foot meets the ground heel first, the vastus lateralis muscle is more activated, while if the foot meets the ground with the front part first, the gastrocnemius muscle is more activated. There is a certain difference in the moment when force is created in the joints (ankle, knee, hip) depending on which part of the foot meets the ground.

When setting the foot with the heel first, the force created in the amortisation phase is 20% greater than when it is set with the front part first, whereas in the stretching phase, the force created is 40% stronger if the foot first touches the ground with the front part than the heel. Jacoby and Fraley (1995) stated that regularity in setting the foot on the ground during take-off was one of the key factors for high jump success. Besides, Saratlija (2020) said that an adjusted activation of the arms and the sweeping leg in the take-off phase enabled the creation of a higher ground reaction force, thus improving the success of the jump.

The significantly better results achieved in the high jump suggest that children's achievements are the result of motor learning and improving the average result of the take-off duration variable. Barić (2006) stated that the process of learning and perfecting a motor ability comes gradually and is achieved through repetition. Gruić (2014) said that technique, motor knowledge, motor stereotypes, kinetic chains, biomechanically optimised space-and-time variables, and parameters are unbreakably linked terms in the logical, semantic and any other sense. Observing results from the physiological point of view, and in line with previous research, it is probably a case of adaptation at the level of neural plasticity, where the motor programme is created that improves jump performance. More concretely, the concept of "plasticity" assumes change in the performance of certain functional programmes, which is likely what happened to the participants in our study. In this research the nervous-muscular changes were not monitored, which is additionally important contributor in understanding the factors that can affect the ability to perform the high jump using the scissors technique, i.e., the vertical jump. Some of these factors are maximal stamina, speed of force development, ability to use the stretching and contraction cycle, ability to produce force at high speed, maximal mechanical power, jumping ability and muscular coordination (Kraemer and Newton, 1994). Therefore, it is advisable for future research to include these factors, which can have a significant effect on the successful jumping performance.

Conclusion

The results of this study show that by applying bilateral and unilateral training, significant improvements in high jump performance using the scissors technique can be achieved.

The experimental group that was subjected to the bilateral exercise treatment had on average, greater improvement in their high jump results in the final measurement (EG1/BT – final measurement_1: 6.70%; final measurement_2: 5.37%) than did the experimental group under the unilateral exercise treatment (EG2/UT - final measurement_1: 6.32%; final measurement_2: 6.32%). The two-way analysis of variance (group x time) with repeated measurement of one factor (time) did not confirm a significant interaction of measurement time and the experimental group, nor was a significant effect obtained for the experimental group.

In line with previous research and explanation of the results, adaptations of the central nervous system will probably be foundational. Advances in performance technique and average improvement in certain kinetic variables, such as the averagely shorter take-off duration, yield significant improvement in the vertical jump. The understanding that bilateral training intervention can achieve symmetrical effects like those from unilateral intervention with the dominant leg alone is of extreme importance for symmetrical muscular and locomotor development, and consequently for the practical approach to children. To successfully implement the results of these variables in the physical education system, training and competition performance, a satisfactory level of education among those working with children and young people is necessary. The results will thus have not only scientific relevance, but important practical applicability.

References

Barić, R. (2006). Utjecaj izvora informacija na uspjeh u motoričkom učenju: verbalna uputa, vizualno modeliranje i povratna informacija o izvedbi. Diplomski rad, Filozofski fakultet u Zagrebu (odsjek za psihologiju), Sveučilište u Zagrebu.

Berk, R. A., and DeGangi, G. A. (1983). DeGangi-Berk Test of Sensory Integration Manual. Los Angeles, CA: Western Psychological Services.

Blažević, I., Antekolović, L., and Mejovšek, M. (2006). Variability of high jump kinematic parameters in longitudinal follow-up. *Kinesiology Journal*, *38*(1), 63–71.

Castanharo, R., Veras, M. I. O., Alcantra, C., Miana, A., Manoel, E. J., Proenca, J. E., and Duarte, M. (2011). Asymmetries between lower limbs during jumping in female elite athletes from the Brazilian national volleyball team. *Portuguese Journal of Sport Sciences, 11*(2), 53–56.

Coynel, D., Marrelec, G., Perlbarg, V., Pélégrini-Issac, M., Van de Moortele, P. F., Ugurbil, K., Doyon, J., Benali, H., and Lehéricy, S. (2010). Dynamics of motor-related functional integration during motor sequence learning. *Neuroimage*, *49*(1), 759–766.

Cuckova, T., and Suss, V. (2014). Muscle Imbalance and Body Composition of Elite Junior Female Volleyball Players. *Paripex-Indian Journal of Research*, *3*(4), 1–2.

Čoh, M. and Supej, M. (2008). Biomechanical model of the take-off action in the high jump– A case study. *New Studies in Athletics*, *23*(4), 63–73.

Dapena, J. (1988). Biomechanical analysis of the Fosbury-Flop, part I. *Track Technique*, *104*, 3307–3317; 3333.

Dapena, J., and Flickin T. K. (2006). Scientific services project – high jump. Biomechanics Laboratory, Department of Kinesiology, Indiana University. Available at: https://sportbm.sitehost.iu.e-du/High-Jump-Report-32-2007-Men-lodef.pdf (Accessed: 8. 5. 2021)

Fazlioglu, Y., and Gunsen, O. M. (2011). Sensory motor development in autism. In Mohammed-Reza Mohammadi (ed.), *A Comprehensive Book on Autism Spectrum Disorders,* (pp. 345–68). Rijeka, Croatia: InTech.

Focke, A., Spancken, S., Stockinger, C., Thürer, B., and Stein, T. (2016). Bilateral practice improves dominant leg performance in long jump. *European Journal of Sport Science*, *16*(7), 787–793.

Grouis, G., Kiodou, I., Tsorbatzoudis, H., and Alexandris, K. (2002). Handedness in sport. *Journal of Human Movement Studies*, *43*(4), 347–361.

Gruić, I. (2014). Odnosi sadržajnog, formalnog i funkcionalnog procjenjivanja izvedbi elemenata tehnike u kompleksnim kineziološkim aktivnostima na primjeru sportske igre: rukomet. Zbornik radova 23. Ljetne škole kineziologa, 526–532.

Haaland, E., and Hoff, J. (2003). Non-dominant leg training improves the bilateral motor performance of soccer players. *Scandinavian Journal of Medicine and Science in Sports*, *13*(3), 179–184.

Horga, S. (1993). *Psihologija sporta*. Fakultet za fizičku kulturu, Zagreb.

Jacoby, E. and Fraley, B. (1995). *Complete Book of Jumps*. Champaign, IL: Human Kinetics.

Kovács, I., Tihanyi, J., Devita, P., Rácz, L., Barrier, J., and Hortobágyi, T. (1999). Foot placement modifies kinematics and kinetics during drop jumping. *Medicine and Science in Sports and Exercise*, *31*(5): 708–16.

Kraemer, WJ, and Newton, RU. (1994). Training for improved vertical jump. *Sports Science Exchange*, *7*(6), 1–12.

Marinsek, M. (2016). Lateral asymmetry as a function of motor practice type of complex upper- and lower-limb movement in young children. *Laterality: Asymmetries of Body, Brain and Cognition*, *21*(3), 267–281.

Petrić, V., Kostadin, L., and Peić, M. (2018). Evaluation of an integrated programme of physical exercise with nursery-aged children: impact on motor achievements. *Journal of Elementary Education, 11*(3), 189–200.

Pittenger, V. M., McCaw, T. and Thomas, D.Q. (2002). Vertical ground reaction forces of children during one- and two-leg rope jumping. *Research Quarterly for Exercise and Sport*, *73*(4), 445-449.

Saratlija, P. (2020). Kinematička i kinetička obilježja specifičnih vježbi odraza skakačica u vis. Doktorski rad. Kineziološki fakultet Sveučilišta u Zagrebu.

Sinclair, J., Fewtrell, D., Taylor, P. J., Atkins, S., Bottoms, L., and Hobbs, S. J. (2014). Three-dimensional kinematic differences between the preferred and non-preferred limbs during maximal instep soccer kicking. *Journal of Sports Science, 32*(20), 1914–1923.

Teixeire, L.A., Silva, M.V.M, and Carvalho, M.A. (2003). Reduction of lateral asymmetries in dribbling: The role of bilateral practice. *Laterality, 8*(1), 53–65.

Vujičić, L., Peić, M., and Petrić, V. (2020). Representation of Movement-Based Integrated Learning in Different Physical Environments of an Early Education Institution. *Journal of Elementary Education*, *13*(4), 453–474.

Williams, H. G. (1983). *Perceptual and Motor Development*. Englewood Cliffs, NJ: Prentice-Hall.

Authors:

Sanja Ljubičić, PhD
Externa associate, University of Rijeka, Faculty of Teacher Education, Sveučilišna avenija 6, 51000 Rijeka, Croatia, e-mail: sanja.ljubicic@uniri.hr
Zunanja sodelavka, Univerza v Reki, Pedagoška fakulteta, Sveučilišna avenija 6, 51000 Reka, Hrvaška, e-pošta: sanja.ljubicic@uniri.hr

Ljubomir Antekolović, PhD
Full professor, University of Zagreb, Faculty of Kinesiology, Horvaćanski zavoj 15, 10000 Zagreb, Croatia, e-mail: ljubomir.antekolovic@kif.unizg.hr
Redni profesor, Univerza v Zagrebu, Kineziološka fakulteta, , Horvaćanski zavoj 15, 10000 Zagreb, Hrvaška, e-pošta: ljubomir.antekolovic@kif.unizg.hr

Vilko Petrić, Ph.D
Assistant professor, University of Rijeka, Faculty of Teacher Education, Sveučilišna avenija 6, 51000 Rijeka, Croatia, e-mail: vilko.petric@uniri.hr
Docent, Univerza v Reki, Pedagoška fakulteta, Sveučilišna avenija 6, 51000 Reka, Hrvaška, e-pošta: vilko.petric@uniri.hr