INFLUENCE OF DOMINANT AND NON-DOMINANT BODY SIDE ON SPECIFIC PERFORMANCE IN TAEKWONDO

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Abstract:

To identify the gender-specific influence of dominant laterality of motor abilities on taekwondo techniques performed to the right and left body side, thirty-nine male and eighteen female taekwondoists (age range 10±2 years) underwent two testing sessions to evaluate ambidexterity: (1) motor abilities measured on the left and the right body side; (2) quality of performance of taekwondo leg technique (front kick and roundhouse kick) measured on the right and the left body side. The results of *t*-test indicated gender differences in the taekwondo technique acquisition and flexibility and defined the body asymmetry differences in motor abilities assessed by the variables *grip strength*, *frequency of alternate leg movements* and *alternate hand movements* ($p<.05$). According to the regression analysis results for male athletes, motor abilities measured on both the left and the right side of the body were defined with strong linear correlation with taekwondo basic techniques' performance to both body sides (MC from .75 to .81), while in female athletes, motor abilities measured on the right side of the body were not significant. Gender-based success-related dominant motor abilities profile structure does not condition their influence when it comes to the asymmetric taekwondo performance.

Key words: *sport performance, body asymmetry, gender differences*

Introduction

Ambidexterity is the state of being equally adept in the use of both right and left body sides. People who are naturally ambidextrous are extremely rare. Athletes can become ambidextrous, by practising equally with both hands and legs while their movement versatility with each body side is generally the qualitative factor in determining a person's ambidexterity.

Taekwondo (TKD) is a martial art and modern Olympic sport very popular among boys and girls all over the world and equal mastery of TKD techniques with both body sides is an important factor of TKD competition success. TKD is characterized by specific fast, high and spinning kicks with a movement structure which is highly demanding for most muscle groups of the athletes. Kicking is a typical rapid movement which is moderately or highly dependent on the athletes' ability to generate muscular force and power (Hakkinen, 1991; Augustsson & Thomee, 2000; Wisloff, Castagna, Helgeurd, Jones, & Haff, 2004; Wasik, 2006, 2009) and those motor abilities (MA) along with flexibility (Marković, Mišigoj-Duraković, & Trninić, 2005) should be investigated in the concept of technical mastery performance in TKD.

The fact that left-handed and right-handed people are able to develop motor skills in their non--dominant side should be considered an advantage in the training process in order to achieve better sport results. In this paper we investigate the dominance of the left or right body sides on the performance of basic leg TKD techniques, separately, according to gender, supposing that those athletes who are ambidexterous will be more successful in TKD competitions too. Previous investigations found significant gender differences in MA (Billaut & Bishop, 2009; Temfemo, Hugues, Chardon, Mandengue, & Ahmaidi, 2009; Quatman, Ford, Myer, & Hewett, 2006; Martin, Dore, Twisk, Van Praagh, Hautier, & Bedu, 2004) motor performance (Davis, et al., 2006; Davies, 1990) and motor learning (Dorfberger, Adi-Japha, & Karni, 2009). Therefore, it is an assumption that differences between male and female athletes may also occur in the field of technical mastery and TKD sport – specific ambidexterity, probably connected with natural body asymmetry. According to Jaszczak (2008) body

asymmetry has three types: (1) morphological, expressed as the differences in: circumference, length, width, shape or proportions between even organs; (2) functional, variance in frequency of use, accuracy of movement and (3) dynamical, differences in muscle strength between the body sides. Motor training refers to performance improvement, expressed by a decrease in error (Gallasch, Christova, Kren, Kosev, & Rafolt, 2009), and that could be connected with hand preference or with the dominant or non-dominant body side performance (Stevens-Smith, 2009). Garry, Kamen, and Nordstrom (2004) found hemispheric differences in cortical excitability associated with a better performance in a pegboard test with the dominant hand and hemispheric asymmetries in post-exercise motor evoked potential facilitation.

The aim of this investigation was to determine the differences in acquisition of technique between male and female taekwondoists and to identify the influence of motor abilities (MA) measured on the left and the right body side on two aspects of TKD technique (front kick and roundhouse kick) performed to the right and the left body side.

For that purpose we:

- analysed and compared gender differences in MA measured on the left and the right body side;
- analysed and compared gender differences in the performance of two aspects of TKD technique (front kick and round house kick) performed to the right and left body side and calculated the coefficient of asymmetry (CA);
- defined the predictability of MA of the dominant and the non-dominant body side for the left and the right TKD techniques.

The authors believe that the objectives they specified were not only of scientific, but also of practical importance, since any possible MA body side determined specificities will be of high applicability in adjusting the TKD development training plans.

Methods

Participants

Thirty-nine male (age range 10±2 years) and eighteen female (age range 10±2 years) TKD athletes were recruited. Each volunteer, their parents and trainers gave written informed consent. The results of average body weight, body height, BMI, years of training and hours of weekly training sessions are presented in Table 1 for boys and girls separately.

The athletes participated in TKD competitions at the national (90%) and international (60 %) level. All of the subjects were injury-free and right--handed.

Procedure

Both male and female athletes were subjected to the same tests that evaluate ambidexterity by: (1) MA measured on the left and the right body side; (2) performance quality of TKD leg technique (front kick and roundhouse kick) measured to the right and the left body side and (3) a calculation of coefficient of asymmetry (CA).

The MA testing session was completed first, followed by a video recording of the performance of TKD leg techniques to both body sides. These recordings were used by three judges – experts in the evaluation of the level of performance quality (Delaš, Miletić, & Miletić, 2008; Miletić, Katić, & Maleš, 2004). These two phases of measuring were performed in two days and all the tests were performed in the morning.

Variables

The sample of variables encompassed: (1) a group of predictor, MA variables measured on the right and the left body side; (2) a group of criterion variables, two aspects of TKD technique performed to the right and the left body side and (3) a calculated coefficient of asymmetry (CA).

Motor abilities

MA variables were chosen so as to provide the best possible assessment of the basic motor abilities considered to be most relevant for a successful TKD performance (Marković, 2007; Marković, et al., 2005).

The sample of variables used to assess physical fitness consisted of 6 motor tests measured on both body sides: for assessing frequency of movement (*foot tapping* - f/15 sec, *hand tapping* - f/15 sec); explosive power test (*triple jump* - cm), dynamic muscular strength endurance tests (*one-leg squat* - f/min); maximal strength test (*grip strength* - kg), tests assessing flexibility (*side splits* - degree);

Foot tapping – to tap with the foot against tapping boards alternately for 15 seconds; the number of correct cycles during 15 seconds (1 cycle=2 taps) are counted.

Hand tapping – to tap with the fingers against tapping boards alternately for 15 seconds; the number of correct cycles during 15 seconds (1 cycle=2 taps) are counted.

Triple jump – to jump repeatedly three times as far ahead as possible with one leg from the spot;

One-leg squat – to stand up and sit down as many times as possible in a minute, using one leg only, from sitting position on a bench; fingers are interlaced behind the head. The result of the test is the number of correct actions of standing up.

Grip strength – to squeeze a *Takei* dynamometer as strongly as possible with a hand, which is in a rotationally neutral position; the width of the grip is individually adjusted; the test is executed

in the standing position, with the arm extended downwards along the body. The results are recorded in kg.

Side split – lying on one's side; to perform the maximum adduction with the upper leg stretched and kept in the final position. The results are recorded in degrees.

The tests assessing frequency of movement, explosive power, maximal strength and flexibility were performed three times and only the best results were used for the analysis. The test assessing dynamic muscular leg strength endurance was performed only once.

Performance quality of taekwondo techniques

All athletes performed the following two TKD specific elements with the dominant and then with the non-dominant side of the body: front kick and roundhouse kick. The authors selected elements which they considered to be the basic leg techniques. Punching and kicking are the basic techniques frequently used in competition fights and represent a principle focus of TKD training.

As the study requested, basic leg TKD techniques were chosen (front kick and roundhouse kick). In the structure of TKD techniques, these techniques should be mastered for the basic TKD ranks (yellow and high yellow belt), and they are used in TKD competitions. The author's main idea was to construct tests to: (1) identify differences in performance between the left and the right body sides; (2) evaluate performance of TKD beginners.

Front kick (Ap Chagi) starting phase (1-2): from the fighting stance the attacking leg is bent at the knee, raised up to the waist level and simultaneously moved close to the body. *Execution (3)*: the foot is stretched forward using a shoving movement. The hit is executed by the ball of the foot. *Closing phase (4-5)*: the foot is moved back via the same way.

Roundhouse kick (Dollyo Chagi) starting phase (1-2): from the fighting stance the attacking foot and leg are moved upward to the waist level, the leg is bent at the knee, and standing on the other foot the practitioner turns his/her body round. *Execution (3)*: when the knee of the attacking leg and foot are in the same line pointing to the target with the heel of the standing foot, the round movement continues into a rapid stretching of the hitting foot. *Closing phase (4-5)*: The foot is taken back via the same way.

Only the best performance was evaluated. The judges were previously educated to evaluate a performance on a nine-level scale.

Figure 1

Figure 2

Three judges who are TKD experts (black belt holders from 2nd to 5th dan, national and international championships medalists with a minimum of 6 years of coaching experience) evaluated the subjects' performance to the dominant and to the non-dominant side in a way that for each standardized error they subtracted 1 point from the maximum total grade, which was excellent (10). The list of the standardized errors: the leg is not bent at the knee before the kick phase; the foot and the toes are not in the correct position at the moment of kicking; the kick is not performed above the belt level; the support leg foot is not on the floor with its entire length at the moment of kicking; the leg is not correctly returned to the starting position; the subject looks around during the kick; the leg is not bent at the knee after the kick phase; the kick is not performed dynamically correctly; the balance is not satisfactory.

Coefficients of asymmetry calculation

Three judges evaluated the subjects' performance to the dominant and to the non-dominant side of the body and those scores were inserted in the following formula (Jastrjembskaia & Titov, 1999):

$$CA = (D - ND)/ D \times 100$$

where: CA = coefficient of asymmetry; D = dominant side of the body; ND = non-dominant side of the body. It is important to emphasize that the dominant side of the body of all the subjects was right (left support leg).

Statistical analysis

The data were analysed with the use of the Statistica for Windows 7.0 software package. Basic descriptive parameters of all the variables were calculated separately for female and male athletes (mean value and standard deviation) as well as Kolmogorov-Smirnov test assessing the normality of distributions. The independent-sample *t*-test was used to determine the differences between genders in all variables. The dependent-sample *t*-test was used to determine the differences between the body sides for the same tests. Finally, multiple regression analyses were computed to determine the relations between MA measured on the left and on the right body side and three TKD specific elements performed with the dominant and the non-dominant side of the body.

Results

Basic descriptive parameters of MA measured on the left and right body side and the two aspects of technique performed with the left and the right body side are reported in Table 2 for female and male athletes. According to Kolmogorov-Smirnov test verifying normality of the distribution there were no significant differences between the observed and the expected normal distributions in all the tests for female and male population (.09-.23). The inter-observer agreement coefficients for all the TKD techniques performance quality variables exceeded the value of .85 (.863-.920) which confirmed the high reliability of the tests.

Table 1. Descriptive statistics (means and standard deviations – SD)

	Female (n=18)	Male (n=39)
	Mean±SD	Mean±SD
Age (years)	10±2	10±2
Body height (cm)	146.7±10.9	142.2±11.2
Body weight (kg)	38.6±7.6	38.2±9.1
BMI	24.1±5.3	25.2±6.7
Years of training	3.0±1.5	3.4±1.6
Weekly training sessions	4.7±3.8	4.9±2.1
TKD belt*	5.9±1.8	5.8±2.1

*TKD belts are marked as 10, 9, 8, 7, 6, 5, 4, 3, 2, 1 geup (from the white belt – 10 geup to the red belt with a black stripe – 1 geup)

T-test for dependent samples (Table 2) showed significant differences between the left and the right body side for the variables of MA in the tests assessing the grip strength, the frequency of alternate movements of the arm and the frequency of the alternate leg movements in both genders. There were significant differences in favour of the right body side, which was expected, because the sample of the subjects consisted of the right-handed persons only. Other tests of motor abilities (flexibility, strength and explosive leg strength) and performance quality test of two basic TKD techniques did not show either in boys or in girls any significant differences between the left and the right side of the body.

T-test for independent samples (Table 2) showed the gender differences in variables for the assessment of the flexibility (for both body sides) and in variables evaluating performance quality of the front and roundhouse left and right kicks. There were significant differences to the advantage of the girls. Means of CA of each element for the evaluation of TKD kicks performance quality showed a higher ambidexterity in the male population but not with the significant differences between the populations.

Eight multiple regression analyses were conducted (Table 3 and 4) for each gender separately with the MA measured on both body sides as the predictors and two basic TKD techniques performed with both body sides as the criterion.

Table 2. Basic descriptive parameters of motor abilities measured on both body sides; three aspects of TKD technique in female and male subjects and the results of the independent-samples t-test

	Female (n=18)	Male (n=39)	*t*-values
Motor abilities measured on the left and the right side of the body			
One-leg squat – left leg *(f)*	24.2±19.1	23.8±18.6	-.07
One-leg squat – right leg *(f)*	26.6±19.1	22.2±16.7	-.89
Triple jump – left leg *(cm)*	413.1±92.9	400.6±105.4	-.43
Triple jump – right leg *(cm)*	425.3±87.9	404.0±107.3	-.74
Grip strength – left fist *(kg)*	17.9±4.8**	16.8±4.2**	-.82
Grip strength – right fist *(kg)*	19.3±5.1**	17.7±4.4**	-1.27
Foot tapping – left leg *(f)*	36.2±3.8**	33.9±4.8**	-1.84
Foot tapping – right leg *(f)*	37.8±4.3**	35.5±5.4**	-1.59
Hand tapping – left hand *(f)*	30.5±4.4**	28.4±5.1**	-1.49
Hand tapping – right hand *(f)*	33.6±10.2**	31.1±8.0**	-.99
Side split – left leg *(°)*	89.3±17.2	79.3±10.8	-2.67*
Side split – right leg *(°)*	87.5±12.4	77.9±9.9	-3.14*
Basic TKD technique performed with the left and the right side of the body			
Right front kick (RFK)	7.9±1.9	5.9±2.3	-3.15*
Left front kick (LFK)	7.7±1.8	5.9±2.3	-2.89*
Right roundhouse kick (RRK)	7.2±1.6	5.4±2.5	-2.82*
Left roundhouse kick (LRK)	6.8±2.0	5.4±2.3	-2.30*
Coefficients of asymmetry			
CA front kick	.01±.09	-.09±.71	-.60
CA round kick	-1.09±.23	-.10±.71	-.96

Values are means and lower-upper bound of confidence intervals; significant differences between male and female athletes: *p<.05.
Dependent-samples t-test; significant differences between the right and the left body side: **p<.05

Table 3. Regression analysis of motor abilities of right and left side of the body with two aspects of TKD technique performed on right and left body side (girls)

	RFK		LFK		RRK		LRK	
Right body side	BETA	p	BETA	p	BETA	p	BETA	p
One-leg squat	.26	.49	.41	.32	-.22	.62	-.06	.89
Triple jump	.30	.28	.31	.31	.27	.40	.52	.10
Grip strength	-.03	.93	.33	.38	-.17	.66	-.41	.29
Foot tapping	.15	.80	-.39	.55	.69	.33	.66	.32
Hand tapping	.35	.45	.53	.30	-.14	.79	-.23	.64
Side split	.31	.15	.37	.13	.22	.37	.17	.46
	MC .78 PMC .06 PV 61.22		MC .73 PMC .13 PV 53.64		MC .68 PMC .23 PV 43.61		MC .73 PMC .14 PV 52.93	
Left body side								
One-leg squat	.13	.58	.35	.18	-.19	.26	-.19	.37
Triple jump	.39	.08	.31	.18	.64	.00	.72	.00
Grip strength	-.12	.63	.01	.96	.20	.27	-.12	.60
Foot tapping	.28	.37	-.06	.84	.31	.17	.73	.02
Hand tapping	.39	.18	.52	.10	-.20	.33	-.41	.11
Side split	.23	.26	.35	.11	.38	.02	.10	.57
	MC .82 PMC .03 PV 76.34		MC .80 PMC .04 PV 63.95		MC .91 PMC .00 PV 83.72		MC .87 PMC .00 PV 75.68	

Legend: MC – multiple correlation of the criterion variable and the predictive system; PMC – importance of the multiple correlation coefficient; PV – percentage of the explained variance; RFK – right front kick, LFK – left front kick; RRK – right roundhouse kick; LRK – left roundhouse kick

Table 4. Regression analysis of motor abilities of the right and the left side of the body with the two aspects of TKD technique performed with the right and the left body side (boys)

	RFK		LFK		RRK		LRK	
Right body side	BETA	p	BETA	p	BETA	p	BETA	p
One-leg squat	.20	.10	.28	.02	.22	.10	.22	.07
Triple jump	.15	.30	.13	.34	.32	.05	.33	.03
Grip strength	.27	.08	.30	.04	.18	.26	.11	.47
Foot tapping	.36	.06	.42	.02	.29	.15	.34	.08
Hand tapping	.19	.26	.12	.48	.11	.56	.11	.54
Side split	.14	.23	.18	.12	.16	.21	.29	.02
	MC .79 PMC .00 PV 62.15		MC .81 PMC .00 PV 65.39		MC .75 PMC .00 PV 56.75		MC .78 PMC .00 PV 61.09	
Left body side								
One-leg squat	.23	.58	.30	.01	.28	.02	.29	.01
Triple jump	.22	.08	.15	.32	.16	.28	.16	.30
Grip strength	.28	.63	.32	.04	.32	.03	.23	.12
Foot tapping	.27	.37	.29	.16	.28	.17	.28	.18
Hand tapping	.17	.18	.16	.45	.15	.48	.17	.42
Side split	.18	.26	.19	.09	.29	.01	.36	.00
	MC .79 PMC .00 PV 63.30		MC .79 PMC .00 PV 63.19		MC .80 PMC .00 PV 64.40		MC .80 PMC .00 PV 63.61	

MC – multiple correlation of the criterion variable and the predictive system; PMC – importance of the multiple correlation coefficient; PV – percentage of the explained variance; RFK – right front kick, LFK – left front kick; RRK – right roundhouse kick; LRK – left roundhouse kick

As regards TKD basic techniques of the female athletes' performance (Table 3), motor abilities measured on the left side of the body were defined with a very strong linear correlation with TKD basic techniques performance quality with both body sides (MC from .78 to .91). However, a correlation of MA measured on the right side of the body with TDK basic techniques performance quality, defined by multiple regression, was not significant.

The variable assessing explosive power with the left leg had significant predictive values (BETA coefficients) on performing both the left and the right roundhouse kick. Further, the variable assessing flexibility with the left leg had significant predictive values on the right roundhouse kick and the variable assessing frequency of alternate movements with the left leg had significant BETA coefficients with the performance of the left roundhouse kick.

The results of the regression analysis (Table 4) in the subsample of the male athletes indicated that the entire group of the studied MA variables measured on both body sides had a statistically significant contribution to the TKD basic techniques performance quality also on both sides of the body (MC from .64 to .80).

From the aspect of MA predictors (BETA coefficients) among the male population, the variables assessing strength (*one-leg squat* and *grip strength*) on both body sides had significant predictive values on performance quality of the left front kick as well as on the right and the left roundhouse kick. The variable assessing explosive power (*triple jump*) on the right body side and flexibility (*side splits*) on both the right and the left body side had significant predictive values on performance quality of the left and the right roundhouse kick.

Discussion and conclusions

Gender differences in MA and motor performance during prepubescence are small and may relate more to environmental factors (intensity and duration of activity, parental influence) than to intrinsic differences between genders, with the exception of flexibility, favouring the girls (Keller, 2008). Puberty is a pivotal time when boys start to dominate in MA and motor performance (Bencke, Damsgaard, Sackmose, Jorgensen, Jorgensen, & Klausen, 2002; Beunen, Thomis, Peeters, Maes, Claessens, & Vlietinck, 2003; Martin, et al., 2004; Armstrong, Welsman, & Kirby, 2000) and obtain results which correspond to previous research studies, according to which the gender differences in MA intensify after the age of 14 (Temfemo, et al., 2009, Martin et al., 2004; Malina & Bouchard, 1991) and are all in favour of boys with the exception of flexibility (Raudsepp & Jürimäe, 1996).

The established significant gender differences in the flexibility tests, in favour of the girls correspond

to previous research studies (Thomas & Thomas, 1988), while there are no research studies which could confirm a better technical performance of the front and roundhouse kick in TKD in the girls. The better the flexibility, the better technical performance of leg techniques. That is why the development of flexibility will improve the technical performance of leg techniques in TKD.

The established differences between the left and the right body side in the grip strength, frequency of the arm and leg movements in TKD competitors of both genders represent important information to TKD training practice, where it may be extremely important for success in competitions when both the left and the right techniques are used. The obtained results indicate a good training process has been conducted when it comes to the lower extremities (strength, explosiveness, and flexibility) and the need to improve the training process for the upper extremities, given the fact that the weaker body side could be significantly improved.

The presented results of regression analyses demonstrate all the complexity and conditions of a good performance of the basic left and right TKD leg techniques.

In the sample of girls, the performance of the left and the right TKD leg techniques was significantly related to MA measured on the left body side, while in the sample of boys, the performance of the left and the right TKD leg techniques was equally related to MA measured on both body side. In this matter, we cannot say that the left side is always the non-dominant side of the body. Roundhouse kick is a technical element based on the explosive power of the support leg – which, in most cases, is the left one, so the high flexibility and the frequency of the movement of the left leg in this case will influence the technical quality of performance. Consequently, girls rely on those abilities which are predominantly developed in that phase of growth and development. It means that technical mastery and TKD sport-specific ambidexterity during preadolescence are also trainable.

Young girls and boys have a similar force-generating ability (Davies, 1990) and body mass and leg muscle volume influence their performance, so morphological asymmetry and MA predominantly included in performing a specific motor task can cause different results of MA measured on the different body sides.

In the sample of boys, the strength of the left and right body side (measured by *one-leg squat* and *grip strength* test) is equally correlated to the performance of the left front kick technique, while explosive power and flexibility of the right body side and the strength and flexibility of the left body side are predominant in the performance of both side roundhouse kick techniques. We suppose that the boys rely more on strength in their performance (Ingle, Sleap, & Tolfrey, 2006; Armstrong, et al., 2000), whereas the girls rely more on flexibility, but the reason why the girls' performance was not related to MA measured on the right body side is still to be researched.

Jumping performance increases during growth and it is slightly more expressed in boys in prepubescence (Thomas & French, 1985). Also, explosive power explosive power, necessary for a better performance of motor movements such as kicks, is used more in boys than in girls.

The importance of leg explosive power in taekwondo is to be expected (Heller, Peric, Dlouha, Kohlikova, Melichna, & Novakova, 1998; Marković, et al., 2005). These authors reported that explosive leg strength, measured by the *squat jump* test, was not a significant predictor of the performance rank in female TKD athletes. Since performance of squat jumps depends mostly on the contractile strength of muscles, the ability to express maximal strength in the stretch-shortening cycle movements could be more important to TKD performance than the maximal strength expression in the concentric-only movements. There is no difference in the asymmetry in the tests assessing explosive power in this research, which is why we assume that explosive power is responsible for the better lateral correlation of MA and motor performance in the boys.

In this research, strength assessment tests (*one-leg squat* and *grip strength*) established an important correlation with TKD performance only in the sample of boys. Recent work also suggests that static and explosive power development during the period of growth is influenced by linear growth, weight, and muscle size and is moderately inherent (Beunen, et al., 2003), therefore it is possible that the use of those MA during motor performance is also genetically determined in favour of the boys. It might be expected that small increases in muscle mass in boys prior to puberty would enhance their performance.

Due to the genetic determination of psychomotor speed and explosive power, the left or right lateral domination cannot be explained only by training process effects. Agility and coordination, in contrast to movement frequency, can be influenced after puberty, generally through the component of force (Šimek, Milanović, & Jukić, 2008) and should be applied in TKD training as laterally specific exercises – technique practising on both body sides.

According to this study authors' opinion, the obtained results concerning the specific importance of the dominant and/or non-dominant body side in TKD, between boys and girls respectively, should be applied in developing tapering methods in TKD training. That is especially important for coaches when choosing training methods through non-physiological factors of the taper (Pyne, Mujika,

& Reilly, 2009) in order to manipulate the type, frequency, duration and intensity of training to enhance or optimize the performance.

In an evaluation of the training process the determination of the dominant body side as well as its influence on the performance of basic techniques, have a major impact on sport performance. So, the definition of the success-related dominant MA profile structure in TKD may be valuable both scientifically and practically.

In a selection of athletes, the focus should be on those traits and abilities which have the most significant influence on sporting performance, and on those which are predominantly under the prevailing influence of genetic factors. Ambidexterity in TKD is a combination of those two factors.

In this paper the authors deal with functional (frequency of movements and motor performance) and dynamical (differences in muscle strength between the body sides) aspect of asymmetry, and in future investigations, the morphological impact on performance with the dominant or non-dominant body side should be investigated.

Performance quality of the front and roundhouse kick depended on the athletes' flexibility and their ability to generate muscular force and power (Hakkinen, 1991; Augustsson & Thomee, 2000; Wisloff, Castagna, Helgeurd, Jones, & Haff, 2004), but the influence of MA laterality is gender-specific and should be investigated further, including variables assessing the morphological, functional and dynamical body asymmetry.

Dominant MA in both genders is on the right side, but it does not condition their generation when it comes to the asymmetric performance of basic TKD leg techniques. We suppose that gender--related differences in generating MA derive from the level of development of specific MA, characteristic for prepubescence, and from their genetic determination.

Although no statistically important CA in the technical performance of basic TKD leg techniques has been recorded, we may suppose that those athletes who have managed to develop the abilities of the weaker body side to a higher level will be more successful in TKD.

Practical implications

- Applied procedures for assessing ambidexterity are suitable for monitoring the training process in TKD.
- Prepubescence is a suitable period for the development of technical mastery and TKD sport--specific ambidexterity.
- TKD training in both genders should be programmed with more strength and speed exercise contents done with the weaker body side.
- The development of flexibility will improve the technical performance of leg techniques in TKD.

References

Armstrong, N., Welsman, J.R., & Kirby, B.J. (2000). Longitudinal changes in 11-13 year olds' physical activity. *Acta Pediatrica*, *89*, 775-780.

Augustsson, J., & Thomee, R. (2000). Ability of closed and open kinetic shin tests of muscular strength to assess functional performance. *Scandinavian Journal of Science and Medicine in Sports*, *10*, 164-168.

Bencke, J., Damsgaard, R., Sackmose, A., Jorgensen, P., Jorgensen, K., & Klausen, K. (2002). Anaerobic power and muscle strength characteristics of 11 years old elite and non-elite boys and girls from gymnastics, team handball, tennis and swimming. *Scandinavian Journal of Science and Medicine in Sports*, *12*, 171-178.

Beunen, G., Thomis, M., Peeters, M., Maes, H.H., Claessens, A.L., & Vlietinck, R. (2003). Genetics of strength and power characteristics in children and adolescents. *Pediatric Exercise Science*, *15*, 128-138.

Billaut, F., & Bishop, D. (2009). Muscle fatigue in males and females during multiple-sprint exercise. *Sports Medicine*, *39*, 257-278.

Davies, B.N. (1990). The relationship of lean limb volume to performance in the handgrip and standing long jump tests in boys and girls, aged 11.6-13.2 years. *European Journal of Applied Physiology*, *60*, 139-143.

Davis, D.S., Bosley, E.E., Gronell, L.C., Keeney, S.A., Rossetti, A.M., Mancinelli, C.A., Petronis, J.J. (2006). The relationship of body segment length and vertical jump displacement in recreational athletes. *Journal of Strength and Conditioning Research*, *20*, 136-140.

Delaš, S., Miletić, A., & Miletić, D. (2008). The influence of motor factors on fundamental movement skills – the differences between boys and girls. *Facta Universitatis Series Physical Education*, *6*, 31-39.

Dorfberger, S., Adi-Japha, E., & Karni, A. (2009). Sex differences in motor performance and motor learning in children and adolescents: An increasing male advantage in motor learning and consolidation phase gains. *Behavioural Brain Research*, *198*, 165-171.

Gallasch, E., Christova, M., Krenn, M., Kossev, A., & Rafolt, D. (2009). Changes in motor cortex excitability following training of a novel goal-directed motor task. *European Journal of Applied Physiology*, *105*, 47–54.

Garry, M.I., Kamen, G., & Nordstrom, M.A. (2004). Hemispheric differences in the relationship between corticomotor excitability changes following a fine-motor task and motor learning. *Journal of Neurophysiology*, *91*, 1570–1578.

Hakkinen K. (1991). Force production characteristics of leg extensor, trunk flexor and extensor muscles in male and female basketball players. *Journal of Sports Medicine and Physical Fitness*, *31*, 325-331.

Heller, J., Peric, T., Dlouha, R., Kohlikova, E., Melichna, J., & Novakova, H. (1998). Physiological profiles of male and female taekwon-do (ITF) black belts. *Journal of Sport Science*, *16*, 243-249.

Ingle, L., Sleap, M., & Tolfrey, K. (2006). The effect of a complex training and detraining programme on selected strength and power variables in early pubertal boys. *Journal of Sport Science*, *24*, 987-997.

Jakubiak, N., & Sunders, D.H. (2008). The feasibility and efficacy of elastic resistance training for improving the velocity of the Olympic taekwondo round house kick. *Journal of Strength and Conditioning Research*, *22*, 1194-1197.

Jastrjembskaia, N., & Titov, Y. (1999). *Rhythmic gymnastics*. Champaign, IL: Human Kinetics.

Jaszczak, M. (2008). The dynamical asymmetry of the upper extremities during symmetrical exercises. *Human Movement*, *9*, 116-120.

Keller, B.A. (2008). State of the art reviews: development of fitness in children: the influence of gender and physical activity. *American Journal of Lifestyle Medicine*, *2*, 58-74.

Malina, R.M., & Bouchard, C. (1991). *Growth, maturation, and physical activity*. Champaign, IL: Human Kinetics.

Marković G. (2007). Poor relationship between strength and power qualities and agility performance. *Journal of Sports Medicine and Physical Fitness*, *47*, 276-283.

Marković, G., Mišigoj-Duraković, M., & Trninić, S. (2005). Fitness profile of elite Croatian female taekwondo athletes, *Collegium Antropologicum*, *29*(1), 93-99.

Martin, R.J.F., Dore, E., Twisk, J., Van Praagh, E., Hautier, C.A., & Bedu, M. (2004). Longitudinal changes of maximal short-term peak power in girls and boys during growth. *Medicine and Science in Sports and Exercise*, *36*, 498-503.

Miletić, D., Katić, R., & Maleš, B. (2004). Some anthropological factors of performance in rhythmic gymnastics novices. *Collegium Antropologicum*, *28*(2), 727-737.

Pyne, D.B., Mujika, I., & Reilly, T. (2009). Peaking for optimal performance: Research limitations and future directions. *Journal of Sport Science*, *27*, 195-202.

Quatman, C.E., Ford, K.R., Myer, G.D., & Hewett, T.E. (2006). Maturation leads to gender differences in landing force and vertical jump performance: A longitudinal study. *American Journal of Sports Medicine*, *34*, 806-813.

Raudsepp, L., & Jürimäe, T. (1996). Physique and physical fitness in prepubertal children. *Acta Kinesiologiae Universitatis Tartuensis*, *1*, 49-58.

Stevens-Smith, D. (2009). Profiles of dominance in physical education. *Kinesiology*, *41*(1), 40-51.

Šimek, S., Milanović, D., & Jukić, I. (2008). The effects of proprioceptive training on jumping and agility performance. *Kinesiology*, *39*(2), 131-141.

Temfemo, A., Hugues, J., Chardon, K., Mandengue, S.H., & Ahmaidi, S. (2009). Relationship between vertical jumping performance and anthropometric characteristics during growth in boys and girls. *European Journal of Pediatrics*, *168*, 457-464.

Thomas, J.R., & French, K.E. (1985). Gender differences across age in motor performance: a metaanalysis. *Psychological Bulletin*, *98*, 260-282.

Thomas, J.R., & Thomas, K.T. (1988). Development of gender differences in physical activity. *Quest*, *40*, 219-229.

Wasik, J. (2006). Physical parameters of the kick in taekwondo. *Archives of Budo*, *2*, 28-30.

Wasik, J. (2009). Structure of movement of a turning technique used in the event of special techniques in taekwondo. *Archives of Budo*, *5*, 111-115.

Wisloff, U., Castagna, C., Helgerud, J., Jones, R., & Hoff, J. (2004). Strong correlation of maximal squat strength with sprint performance and vertical jump height in elite soccer players. *British Journal of Sports Medicine*, *38*, 285-288.

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UTJECAJ DOMINANTNE I NEDOMINANTNE STRANE TIJELA NA SPECIFIČNU USPJEŠNOST U TAEKWONDOU

Radi utvrđivanja spolnih razlika u lateralnoj motoričkoj dominaciji te njihova utjecaja na uspješnost izvođenja nožnih tehnika u taekwondou, provedeno je istraživanje na uzorku od trideset devet djevojčica i osamnaest dječaka, u dobi od 10±2 godine. Mjerenja su u svrhu procjene lateralne motoričke dominacije provedena u dvije etape: (1) mjerenje motoričkih sposobnosti na obje strane tijela; (2) procjena razine izvođenja nožnih tehnika u taekwondou (prednjeg i kružnog udarca) u lijevu i desnu stranu. Prema rezultatima *t*-testa, postoje značajne razlike po spolu u uspješnosti usvajanja prednjeg i kružnog udarca lijevom i desnom nogom i u fleksibilnosti, a utvrđene su i značajne razlike u motoričkim sposobnostima lijeve i desne strane tijela procijenjene varijablama *jakost hvata* maksimalne snage i *frekvencije pokreta ruku i nogu* ($p<.05$). Prema rezultatima regresijske analize u dječaka je utvrđena značajna linearna povezanost između motoričkih sposobnosti mjerenih na lijevoj i desnoj strani tijela te izvođenja nožnih tehnika na dominantnoj i nedominantnoj strani (MC od ,75 do ,81), dok je na uzorku djevojčica značajna linearna povezanost s izvođenjem nožnih tehnika utvrđena samo s motoričkim varijablama mjerenima na lijevoj strani tijela. Dominantna lateralna motorika i razlike zabilježene po spolu u konačnici ne definiraju asimetriju u izvedbi pojednih tehnika.

Ključne riječi: *sportska uspješnost, asimetrija, razlike po spolu*