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CONTRIBUTION OF INLINE SKATING TO LEARNING BASICS OF ALPINE SKIING

DOPRINOS ROLANJA U UČENJU OSNOVA ALPSKOG SKIJANJA

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SUMMARY

Aim of this research was to determine contribution of inline skating to learning basics of alpine skiing. We included 139 participants, who were attributed to two groups - control and experimental. Participants of the experimental group (n=72) were included in 10-days program of learning inline skating while participants pertaining to control group (n=67) did not participate in any kind of sport or recreational program. Before and after inline skating, all participants were tested on six elements of alpine ski technique. Participants of the experimental group had better results on elements of alpine ski technique (4.09 vs. 3.29; p=0.00). Our results suggest inline skating aids better learning of alpine skiing.

Key words: inline skating, alternative sport, alpine ski knowledge

INTRODUCTION

In order to be as efficient as possible in learning alpine ski basics, recreational skiers need to have adequate equipment, appropriate ski terrains, and most of all good ski instructors who will teach alpine skiing according to verified/tested program of alpine ski school. Programs of alpine ski schools should be tailored to the participants needs as well as to conditions in which ski school takes place. Although different countries world-wide use different programs for learning alpine ski basics, all are logically and sequentially structured, meaning that each element of the alpine ski school which is learned represents the basis for the next one (Cigrovski & Matković, 2015). Regardless of the program used, all participants need to adopt specific motions, necessary for controlling movements while on skies which are important during alpine ski turns (Tate, 2007). Recreational level alpine skiing is a seasonal

sport during winter months in alpine ski centres. Mentioned centres usually offer structured programs of alpine ski learning, but in order for the participant to be as efficient as possible it is important to be adequately prepared for skiing (Wojtyczek, Pasławska & Raschner, 2014). Besides conditional trainings, people are encouraged to participate in sports with similar movements as alpine skiing few months prior to going skiing (Roman, Miranda, Martinez & Jesus, 2009). Trainings for competitors in alpine skiing regularly include alternative sports, which burden athletes similarly as skiing trainings. Inline skating is one of the possible ways to train offseason (Kroll, Schiefermuller, Birklbauer & Muller, 2005). It is expected that movements during inline skating improve alpine ski technique (Ropret, 2010). All of the mentioned suggests how knowledge of inline skating could improve learning of alpine skiing. If mentioned correlation would be proven than inline skating could be included in preparation period as a conditioning training for participation in alpine skiing. The aim of our research was to determine the contribution of inline skating on learning basics of alpine skiing in recreational alpine skiers.

METHODS

139 volunteers participated in the investigation after being thoroughly informed about the study procedures and giving informed consents. Their average age was 22.18±1.34 years. All were motorically capable, healthy people, with basic knowledge of alpine skiing. By the method of random choice they were assigned to either experimental (n=72) or control group (n=67). Experimental group of participants were included in inline skating lessons in SkiBoo Sport academy, while control group did not participate in any kind of sport program. At the beginning and after study end (after 10 days of inline skating school) they were tested on six (traversing, uphill turn, basic turn, snowplough, parallel turn and short turn) previously chosen elements of alpine ski technique. Each participant demonstrated all six elements of ski technique, and traversing and uphill turn were performed in left and right side. Participants were graded on a scale one to five by the independent judges. Standardized judging procedure was used (Cigrovski, Matković, B., & Matković, R.B., 2008). Inline skating program lasted 10 days and included two levels. Level one included basic elements of inline skating-basic skating, braking, basic sliding step, pushing with both feet, basic A turn, breaking with basic A turn and level two included transition elements, trainings for self-skating (skating across the street and sidewalks, turning while pushing off by the outer leg, parallel turn, braking in T position, and braking during parallel turn. Both levels were completed during 5 day cycles, and similar conditions were insured for all participants (same number of participants pro group (10), daily hours of learning inline skating (1 hour), hours of practice per day (1 hour), quality of skating equipment, experienced inline skating instructors and appropriate terrain for skating). Obtained results were analysed by statistical package "SPSS for Windows 14.0". Obtained distributions were tested by Kolmogorov-Smirnov test (K-S). Calculated were basic descriptive parameters for six elements used to test alpine ski technique. Significance of difference for the grades obtained on elements of ski technique between the control and experimental groups was determined by Mann-Witney U test. Results were significant with $p<0.05$. Significance of difference between ski knowledge of participants of the two groups was determined by T-test on level of significance $p<0.05$.

RESULTS

In Table 1 are presented results of descriptive statistics during initial evaluation of experimental and control groups

Table 1 Descriptive statistics of initial evaluation of ski knowledge

Groups		N	M	Std. Error M	SD	KS test
experimental	traversing left	72	3.90	0.07	0.60	0.00
	traversing right	72	3.90	0.06	0.57	0.00
	left uphill turn	72	3.45	0.10	0.85	0.00
	right uphill turn	72	3.25	0.09	0.83	0.04
	snowplough	72	3.52	0.09	0.81	0.04
	basic turn	72	3.20	0.10	0.89	0.02
	parallel turn	72	3.20	0.10	0.89	0.01
	short turn	72	2.82	0.11	0.98	0.00
control	traversing left	67	3.86	0.07	0.59	0.00
	traversing right	67	3.85	0.06	0.56	0.00
	left uphill turn	67	3.39	0.10	0.85	0.02
	right uphill turn	67	3.18	0.09	0.81	0.02
	snowplough	67	3.45	0.09	0.80	0.04
	basic turn	67	3.17	0.11	0.90	0.01
	parallel turn	67	3.14	0.10	0.88	0.04
	short turn	67	2.76	0.11	0.94	0.00

Results show slightly better average grades for all analysed elements of alpine ski technique for the participants of experimental group (Table 1).

Table 2 Difference between experimental and control group in skiing knowledge during initial testing

Elements of ski technique	Mann-Witney U test	Sig.
traversing left	2306.00	0.64
traversing right	2300.00	0.62
left uphill turn	2324.00	0.70
right uphill turn	2297.00	0.62
snowplough	2301.00	0.63
basic turn	2349.50	0.78
parallel turn	2331.00	0.73
short turn	2334.00	0.74

Results show that there were no differences between the average grades given to participants of the two groups; so at the beginning of this investigation there were no differences in the knowledge of alpine skiing between the groups (Table 2).

Table 3 Descriptive statistics of final evaluation of ski knowledge

Groups		N	M	Std. Error M	SD	KS test
experimental	traversing left	72	4.47	0.06	0.52	0.00
	traversing right	72	4.41	0.06	0.56	0.00
	left uphill turn	72	4.05	0.07	0.64	0.00
	right uphill turn	72	3.99	0.08	0.69	0.01

	snowplough	72	4.21	0.08	0.68	0.02
	basic turn	72	3.96	0.08	0.75	0.00
	parallel turn	72	3.95	0.08	0.72	0.00
	short turn	72	3.66	0.11	0.94	0.02
control	traversing left	67	3.86	0.07	0.59	0.00
	traversing right	67	3.85	0.06	0.56	0.00
	left uphill turn	67	3.39	0.10	0.85	0.02
	right uphill turn	67	3.18	0.09	0.81	0.03
	snowplough	67	3.45	0.09	0.80	0.04
	basic turn	67	3.17	0.11	0.90	0.02
	parallel turn	67	3.14	0.10	0.88	0.01
	short turn	67	2.76	0.11	0.94	0.00

After 10 days of inline skating school we once again evaluated performance of six elements of alpine ski technique, results are presented in Table 3. Participants of the experimental group achieved better results in all elements of ski technique. K-S test showed that results distributions during final testing do not meet the specified criteria.

Table 4 Differences between experimental and control groups during final testing

Graded elements	Mann-Witney U test	Sig.
traversing left	1086.50	0.00
traversing right	1166.00	0.00
left uphill turn	1382.00	0.00
right uphill turn	1147.00	0.00
snowplough	1151.00	0.00
basic turn	1242.50	0.00
parallel turn	1184.50	0.00
short turn	1222.00	0.00

Results presented in Table 4 suggest significant difference between participants of experimental and control group. Participants of experimental group achieved higher average grades on all tested elements of ski technique (Table 3), suggesting that inline skating school exerted positive effects on learning alpine skiing.

Table 5 Descriptive statistical parameters for final evaluation of alpine ski knowledge for participants of experimental and control groups

Groups	N	M	Std. Error M	SD	KS test
experimental	72	4.09	0.06	0.54	0.41
control	67	3.29	0.09	0.80	0.53

Overall 72 participants participated in inline skating school and achieved better average final marks for ski knowledge (Table 5).

Significance of between the groups difference (4.09 *vs.* 3.29) was tested by independent T-test.

Table 6 Between groups difference in alpine ski knowledge

	t	df	Sig.
Final grade for skiing	6.96	137	0.00
	6.86	113.90	0.00

There were statistically significant between the groups differences in achieved ski knowledge (p=0.00, Table 6).

DISCUSSION

Alpine skiing is a specific motor activity (Hoppeler & Vogt, 2009). Unlike alpine ski competitors who need specific conditioning prior to alpine ski season, recreational skiers are usually not well prepared for the specific requirements during skiing (Stöggl, T., Schwarzl, Müller, Nagasaki, Stöggl, J., Scheiber, Schönfelder & Niebauer, 2016). Conditioning training incorporate exercises of muscles and joints that will be active during skiing. Besides, conditioning trainings are directed to safe and faster acquisition of skiing knowledge as well as prevention of potential injuries during falls or clashes (Ekeland & Rødven, 2009; Hébert-Losier & Holmberg, 2013). For the alpine ski program to be efficient few criteria need to be fulfilled, primarily conditions in which program takes place, quality of ski instructors, quality of program, motivation of both ski instructors and alpine ski school participants and participants' abilities to acquire knew activity (Barth & Bruhl, 2006; Lešnik & Žvan, 2010; Rausavljević, Vidamšek & Pišot, 2012; Cigrovski & Matković, 2015). Last mentioned correlates with participants' motor abilities, which can be influenced by proper/adequate conditioning trainings. Rienhoff, Hopwood, Fischer, Strauss, Baker i Schorer, (2013) showed that knowledge of one sport can aid learning of other similar one. Alpine ski programs for beginners are usually thoroughly and meticulously planned (Lešnik, & Žvan, 2010; Žvan, Lešnik & Supej, 2015). They are based on six or seven days stay in winter ski resorts, with predefined hours during which participants are learning new motor activity. Much of the attention is paid to creating the ideal program of alpine ski schools but a lot less is known about the ways recreational skiers are preparing for skiing season. Results of our study suggest inline skating contributes learning of alpine skiing. Namely, at the beginning of our research participants did not differ in the knowledge of alpine skiing, but after completing 10 days of inline skating school, once again graded performance of elements of alpine ski school revealed significant differences between participants of experimental and control group. Results show better average grades for all analysed elements of alpine ski technique for the experimental group, participating in inline skating school. Kroll, Schiefermuller, Birklbauer & Muller, (2005) suggested that inline skating turns look a lot like ski turns during competitive alpine skiing. It can be expected that adjustment to skies and ski turns will be much faster and easier if recreational skiers have a knowledge in inline skating. We have shown that recreational level inline skating contributes to learning alpine skiing in younger motorically capable people. Similar results were obtained by Roman, Miranda, Martinez & Jesus, (2009) in a group of children age 7 to 13. Participants of the mentioned research were involved in inline skating school prior to learning basics of alpine skiing and this improved acquisition of alpine skiing knowledge, probably due to similar movements used during inline skating and skiing. Participants of our investigation were young adults, previously active in sports, so it would be interesting to test the results on other populations of young people. If the results

would be comparable among different populations, inline skating could be more broadly used in a preparation period for alpine skiing. According to Muehlbauer, Kuehnen & Granacher, (2013), involvement in inline skating two to three times weekly for 90 minutes contributes significantly to balance and strength, which are also important during initial phases of inline skating as well as mastering skiing knowledge. Moreover, inline skating contributes development of cardiovascular capacities, which are important in injury prevention during falls and clashes (Hébert-Losier & Holmberg, 2013; Philippe, Ruedl, Feltus, Woldrich & Burtscher, 2014).

CONCLUSION

Inline skating is a practical activity which can easily be incorporated in every day timetable. If beginners in alpine skiing would use inline skating in the preparation period for alpine ski school it might help them to be more efficient in learning basics of skiing but also advance faster in elements of alpine ski technique. This is also the most practical application of our study results intended for recreational alpine skiers to use inline skating as a conditioning training for alpine skiing.

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SAŽETAK

Cilj ovog istraživanja bio je da se utvrdi doprinos rolanja usvajanju osnova alpskog skijanja. Istraživanjem je obuhvaćeno 139 ispitanika, koji su bili podijeljeni u dvije grupe - kontrolnu i eksperimentalnu. Ispitanici eksperimentalne grupe (n=72) učestvovali su u školi vožnje rolera u trajanju od 10 dana, a ispitanici kontrolne grupe (n=67) za to vrijeme nisu bili uključeni u sportske ili rekreativne programe. Prije i nakon provođenja škole vožnje rolera, svi ispitanici su podvrgnuti testiranju pomoću šest elemenata tehnike alpskog skijanja. Eksperimentalna grupa ispitanika imala je značajno bolje rezultate u elementima tehnike alpskog skijanja (4,09 vs. 3,29; p=0.00). Rezultati ovog istraživanja ukazuju da vožnja rolera može pomoći boljem usvajanju znanja iz alpskog skijanja.

Ključne riječi: vožnja rolera, alternativni sport, znanje alpskog skijanja

APPLICATION OF THE THEORETICAL MODEL IN NORMALIZATION OF VERTICAL JUMP TEST RESULTS WITH RESPECT TO THE BODY MASS

PRIMJENA TEORIJSKOG MODELA U NORMALIZACIJI REZULTATA TESTOVA VERTIKALNOG SKOKA U ODNOSU NA TJELESNU MASU

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SUMMARY

The aim of this study was to examine the efficiency of application of the theoretical model in normalization of motor ability tests in order to neutralize the influence of body mass on muscle strength during various vertical jumps. The sample of participants was consisted of 60 basketball players that play in positions of power forward and center. Independent variables were body mass, body height and body fat percentage, whereas dependent variables were divided into variables that directly and indirectly estimate muscle strength during various vertical jumps. The results of motor ability tests were normalized using a theoretical exponent b=0,67 for direct assessment of muscle strength, while exponent b=0 was used for indirect muscle strength assessment. Based on the obtained results it has been concluded that: 1) before the normalization of the vertical jump test results, there was a moderate positive correlation between the results of the direct muscle strength assessment and body mass (0,44; 0,38) and 2) a correlation between the tests of the indirect muscle strength assessment and body mass was inadequate (-0,09;-0,14). After the application of the theoretical model in normalization of results, it has been noted that correlation coefficients decrease between the tests of direct muscle strength assessment and body mass (-0,08;-0,14). Correlation coefficients in the indirect muscle strength assessment tests remained unchanged (-0,09;-0,14). In that way, we obtained muscle strength results in vertical jumps independently from the body mass.

Keywords: *geometric scaling, vertical jump, maximal muscle strength, body mass.*

INTRODUCTION

One of the constant research subjects in physical education, sport and recreation is the influence of certain body dimensions on one's motor abilities. From all of body dimensions, a influence of body mass on the motor ability results, was the most frequent one. An influence of locomotor apparatus on its movement mechanics is called the scale effect, and relating some mechanical measure that describes movement with certain body dimension is called scaling (Jarić, 1997). Relative power or force is frequently assessed in sport diagnostics with respect to body mass as a quotient of overpowered external loads and body mass. Some authors present normalization of motor ability tests per kilo of body mass (Frontera, Hughes, Lutz & Evans, 1991; Hakkinen, Komi & Alén, 1985). On the other hand, there are authors who consider this way of results normalization inappropriate, thence they proved through a series of studies nonlinear dependence of body dimensions and motor abilities, i.e. the test results are related to $m^{2/3}$ (Nevill, Ramsbottom & Williams, 1992; Jarić, 2002, 2003; Nevill, 1995; Winter, 2005; Marković & Jarić, 2007). Simple example of scale effect significance is seen in the results of weight lifters. Wu Jingbiao who competed in 65 kg category, has set a world record in snatch discipline lifting load of 139 kg. Since relative power is equal to the quotient of overpowered load and body mass, it means that his relative power is equal to 2,48. Besides, if a heavy category athlete (+105 kg) has a relative power of 2,48, it means that he would be able to lift 260,4 kg. However, the world record holder, Bulgarian Aramnau Andrei, in that particular discipline managed to lift 200 kg. On that ground, it could be concluded that body mass and force are not proportionate and with an increase of body mass exertion of muscle power decreases, i.e, it increases with $m^{2/3}$. Another example that indicates the significance of the scale effect is the assessment of relative oxygen consumption (VO_2max) expressed in milliliters per kilo of body mass in minute (ml/kg/min)**.** Although it is known that strength is proportional to the metabolic energy consumption, that is both measures rise with $m^{2/3}$, common practice is to determine relative oxygen consumption by body mass unit (m), not by $m^{2/3}$. In that way, errors are continuously being made in presenting the results of maximum oxygen consumption.

For the results normalization of motor ability tests, today usually two models are being applied: theoretical model or geometrical scaling and experimental model or allometric scaling. Both models are frequently used in practice, and the difference between these two models is very small. If the scale effects would be tested in people with very different body dimensions, the difference between these two models would be more evident. Beside these two models, a model of multiple regression is applied in practice too. Its advantage lays in the facts that in results normalization, apart from body dimensions, other factors that influence functional and motor abilities are included.

Geometric scaling is based on theory of geometric similarity, which implies that difference between two persons exists only in their dimensions. If a body is two times size of another body, then all length measures of that body will be two times bigger, all body surface measures would be $2^2=4$ larger, and all volumes, masses and weights $2^3=8$ larger. Geometric scaling applied on humans considers that all human bodies are of the same shape, and difference exists only in their dimensions. That is why the ratio of various body lengths would be equal for all people. Since the differences in humans' length dimensions are usually smaller than 2:1 ratio, then for practical reasons it would be best to present body dimensions ratio l=1. Number l would be 1.05 if the first person were 5% taller from the second person, or 0.97, if he is 3% shorter than the second person is. Consequently, a person is l times taller or shorter than other person, and

therewith all other length measures (length of extremities, chest circumference, joint diameters ...) are differing for l times. All body surface areas differ l^2 times (body surface area, the area of physiological muscle cross-section, the area of physiological bone cross-section...). All volumes, and more importantly, mass and body weight of a person differ l^3 times (body mass, body parts weight...). For example, if a person is 10% taller than the other person (l=1.1), than all of its body lengths are bigger for 10%, all body area surfaces larger for 21% (l^2=1,21), and all masses and weights 33% heavier (l^3=1,33). Using the principles of geometric scaling, the scale effects on human strength were explained. Recorded muscle force (F) depends on muscle force (Fm) and lever quotient (k), namely $F=Fm \times k$. If a body dimensions change for l times, both moment arms proportionally change and their ratio k=a/b stays unchanged. Therefore, when body dimensions change, lever quotient of locomotor apparatus remains intact. Muscle force (power), inter alia, largely depends on muscle cross-section. As any other surface, it is proportional with l^2, i.e. total muscle power is proportional with l^2 ($F=l^2$). This suggests that results on all strength tests will rise with the square of body height. The most common way of muscle strength results normalization relates to body mass, because body height tends to be unreliable index in normalization of results. It is already mentioned that mass rises with l^3, or vice versa, length increases with cube root of mass $l \sim m^{1/3}$. Hence is $l^2 \sim m^{2/3}$, and the total muscle strength will be equal $F=m^{2/3}$. It can be concluded that the forces that a man generates proportional to the third root of the square of his body mass (Jarić, 1997).

Geometric scaling of different groups of motor ability tests, with respect to the body mass, yields different exponents. Fleishman (1964) allocates vertical jumps into the group of tests that estimate rapid-motions. Accordingly, this study will consider only exponents that relate to that group of tests. The exponents that are used for normalization of results in other motor ability tests would not be presented. The results of direct muscle strength assessment when performing rapid-motions are normalized with $m^{2/3}$, and theoretically proposed exponent for results normalization is $b=0,67$. The results of indirect muscle strength assessment when performing quick moves are normalized with m^0, and theoretically proposed exponent for results normalization is $b=0$ (Aasa, Jarić, Barnekow-Bergkvist & Johansson, 2003; Jarić, 2002).

The aim of this study was to examine the efficiency of application of the theoretical model in normalization of motor ability tests in order to neutralize the influence of body mass on muscle strength during various vertical jumps.

METHODS

Male basketball players (N=60), members of Bosnia & Herzegovina Premier League and First League of Republic of Srpska, participated in this study. Participants were selected according to their playing positions to power forwards and centers, which are commonly known in basketball as inside players. All participants were healthy, without injuries of lower extremities that could affect results of testing. Participants gave formal consent for all measurements and testing.

Variables were divided into two groups. Independent variables were body mass (BM), body height (BH) and body fat percentage (BFP) and they represented morphological characteristics of the participants. Using the bioelectric impedance method (*Tanita BC 418*), a body composition was measured, and precise data on the body mass and percentage of the fat tissue of the subjects were obtained. The height measurer (*Seca*) was used to measure the body height of the examinees. Since tests for the assessment of rapid-motion can be subdivided into tests of direct and indirect muscular assessment, dependent variables are divided into two groups.

Using force platforms (*Globus Ergo Tesys System 1000, Mega Twin Plates*) in direct muscle strength tests, the vertical component of the ground reaction force was measured to two different vertical jumps. Only the exerted power (W) in the concentric phase of the jump with the isolated hands on hips (Countermovement jump-CMJP) was analyzed, and in the jump from the squat position with hands isolated on hips (Squat jump-SJP). In the tests of the indirect estimation of the muscular strength, during the performance of different variants of the vertical jump, the maximum jump height was measured, and the obtained value was expressed in centimeters (cm).

Vertical jump with isolated hands on the hips is performed when the subject from the vertical position lowers to the squat position and, without stopping, at the point of movement direction change (the angle of the thighs and lower legs approximately is 90°), performs the maximum vertical jump. Three attempts were performed, and the best result was recorded for further analysis.

The data were analyzed by descriptive and comparative statistical procedures. Within the descriptive statistics for all variables are determined: arithmetical mean, standard deviation, minimum and maximum. Correlation analysis was applied in the context of the comparative statistics (Pearson method). All collected data were processed using the statistical program Statistics 7.

RESULTS

Table 1 presents the descriptive parameters (arithmetic mean (Mean), standard deviation (SD), range (minimum and maximum values) of morphological characteristics (body height, body mass and body fat percentage) and motor abilities of basketball players (vertical jump with isolated hands on the hips, vertical squat jump with hands isolated on hips).

Table 1. Descriptive parameters of morphological characteristics and motor abilities of basketball players

Variable	Range	Mean ± SD
BH (cm)	179.50-211.00	197.77±8.13
BM (kg)	70.70-115.40	94.59±10.58
BFP (%)	5.50-19.70	12.01±3.34
CMJ (cm)	26.00- 46.00	34.18±4.43
CMJP (W)	3251.60-6298.90	4652.51±679.08
SJ (cm)	24.00-45.00	32.80±4.41
SJP (W)	2662.60-5797.20	4525.77±659.51

Legend: BH-Body height; BFP-Body fat percentage; BM-Body mass; CMJ-Countermovement jump with hands isolated on hips; CMJP-Maximal strength in CMJ; SJ-Squat jump with hands isolated on hips; SJP-Maximal strength in SJ

Table 2 shows the interconnection between the body mass and the results of the motor ability tests of the basketball players before and after the application of the theoretical model in the normalization of the result. Above the diagonal is shown the correlation of the results before,

and below the diagonal after applying the theoretical model in the normalization of motor skills in relation to the body mass.

Table 2. Correlation of the body mass and the results of the motor ability tests of the basketball players before and after the data normalization

	BM	CMJ	CMJP	SJ	SJP
BM	1.00	-0.09	0.44*	-0.14	0.38*
CMJ	-0.09	1.00	0.16	0.96	0.13
CMJP	-0.08	0.41*	1.00	0.06	0.58
SJ	-0.14	0.96	0.34	1.00	0.11
SJP	-0.14	0.36	0.48	0.37*	1.00

Legend: BM-Body mass; CMJ-Countermovement jump with hands isolated on hips; CMJP-Maximal strength in CMJ; SJ-Squat jump with hands isolated on hips; SJP-Maximal strength in SJ

DISCUSSION

Comparing the body dimensions of the tested participants (Table 1) with similar studies (Drinkwater, Pyne & McKenna, 2008; Jeličić, Sekulić & Marinović, 2002 Ostojić, Mazić & Dikić, 2006) one can see that this is about a selected sample of basketball players, whose measures of body mass, body height and body fat percentage are of approximately similar values with the European basketball players at inside positions. Since in most studies, body height, isolated from the other body dimensions, proved to be an unreliable index to normalize results (Jarić, 2002, Marković & Jarić, 2005), the test results were normalized only in relation to the body mass. According to the theory of geometric similarity of the people, exerted muscle strength in the tests of direct muscle strength assessment is dependent on the body mass, and it is necessary to normalize the results, while the indirect assessment tests of muscle strength is not dependent on body mass (Aasa, Jarić, Barnekow- Bergkvist & Johansson, 2003; Marković, Mirkov & Jarić, 2005; Marković & Jarić, 2007). In the sample of students in the Faculty of Kinesiology in Zagreb, Marković tested any difference between the vertical jumping ability tests in concentric and eccentric-concentric mode. He obtained approximately the similar values of theoretically predicted exponents. Analyzing the Squat jump, in relation to the body mass, he found the exponent b = 0.68, that is, b = 0.82 when it comes to Countermovement jump. When he observed the results in relation to the height of the jump expressed in centimeters, he obtained in both jumps exponents near zero (Marković & Jarić, 2005). These results point to the conclusion that it is unnecessary to normalize the results of the tests if they are estimated as the height of the jump expressed in centimeters.

Based on the results presented in Table 2, it can be concluded that prior to the normalization of the results of vertical jump tests, there was a moderate positive correlation between the results of the tests of direct muscle strength and body mass assessment, which is confirmed by the correlation coefficients (0.44; 0.38). Low coefficients of the correlation (-0.09; -0.14) confirm the lack of connection between the tests of an indirect assessment of muscle

strength and body mass. After the application of the theoretical model in the normalization of the results, a decrease in the correlation coefficient between the direct estimation of muscular strength and body mass was noted (-0.08; -0.14). The correlation coefficients in the tests of the indirect muscle power estimation remained unchanged (-0.09; -0.14) because they were normalized with m^0. The obtained results are in line with previous research (Marković & Jarić, 2005, 2007; Nedeljkovic, Mirkov, Kukolj, Ugarković & Jaric, 2007; Crewther, Gill, Weatherby & Lowe, 2009; Crewther, Kilduff, Cook, Cunningham, Bunce, Bracken & Gaviglio, 2012). In addition, due to the normalization of results, the correlation between the results of tests of direct and indirect estimation of muscular strength in the performance of different variants of vertical jumps has increased. This is also confirmed by the correlation coefficients before (0.16; 0.11) and after (0.41; 0.37) normalization of the result.

The applied theoretical model in the data normalization proved to be effective in neutralizing the impact of body mass on the results of motor ability tests. Geometric scaling neutralized the effect of body mass on the manifestation of muscular strength in tests of direct muscle strength assessment when performing different variants of vertical jumps. Similar conclusions were reached by Crewther and associates in two studies (2009 and 2012) testing rugby players in different playing positions.

CONCLUSION

In a broader sense, the aim of the research was to point out the mistakes that are often found in sports practice in testing the functional and motor abilities of athletes, which relate to the normalization of results with respect to the body mass. In the narrow sense, the aim of the research was to prove that by applying the theoretical model in the normalization of the results of motor test of motor abilities successfully neutralizes the influence of the body mass on the manifestation of muscular strength in the performance of various vertical jumps. The results of the research have shown that muscular strength and body mass do not have a linear relationship, but with an increase in body mass, the muscle strength grows slower. Theoretically predicted exponents for the tests of direct and indirect muscular strength assessment in performing rapid-moves, in this case of vertical jumps, successfully neutralize the effect of body mass, so that results of vertical jumps are independent of the body mass. Based on the results, one general conclusion could be made: the body mass influences the exertion of muscular strength in a vertical jump, but does not affect the height of the jump. The significance of the research is also reflected in the fact that the research was conducted on a selected sample of basketball players, characterized by the body dimensions significantly different from the average population. In future research, it would be interesting to analyze the effects of the scale in people with distinctly different body dimensions, different sex, age and race. Then the significance of normalizing the results using one of the models would be even more obvious.

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SAŽETAK

Cilj istraživanja bio je da se ispita efikasnost primjene teorijskog modela u normalizaciji rezultata testova motoričkih sposobnosti u svrhu neutralisanja uticaja tjelesne mase na ispoljavanje mišićne snage pri izvođenju različitih vertikalnih skokova. Uzorak ispitanika činilo je 60 košarkaša koji u svojim timovima igraju na pozicijama krilnog centra i centra. Nezavisne varijable bile su tjelesna masa, tjelesna visina i procenat masnog tkiva, dok su zavisne varijable podijeljene na varijable koje direktno i indirektno procjenjuju mišićnu snagu pri izvođenju različitih vertikalnih skokova. Rezultati testova motoričkih sposobnosti normalizovani su koristeći teorijski predviđen eksponent b=0,67 za direktnu procjenu snage mišića, dok je za indirektnu procjenu snage mišića korišten eksponent b=0. Na osnovu dobijenih rezultata zaključeno je: 1) prije normalizacije rezultata testova vertikalnih skokova postoji umjerena pozitivna povezanost između rezultata testova direktne procjene mišićne snage i tjelesne mase (0,44; 0,38) i 2) izostala je povezanost između testova indirektne procjene mišićne snage i tjelesne mase (-0,09;-0,14). Nakon primjene teorijskog modela u normalizaciji rezultata zabilježeno je smanjenje koeficijenta korelacije između testova direktne procjene mišićne snage i tjelesne mase (-0,08;-0,14). Koeficijenti korelacije u testovima indirektne procjene mišićne snage ostali su nepromijenjeni (-0,09;-0,14). Na taj način dobijeni su rezultati mišićne snage u vertikalnim skokovima nezavisni od tjelesne mase.

Ključne riječi: *geometrijsko skaliranje, vertikalni skok, maksimalna snaga mišića, tjelesna masa*

THE IMPORTANCE OF BALANCE FOR THE PERFORMING THE MAJOR OUTER REAP THROW TECHNIQUE

ZNAČAJ RAVNOTEŽE ZA IZVOĐENJE TEHNIKE BACANJA IZBIJANJEM NOGE OTPOZADI

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SUMMARY

The aim of the research is to determine the relation of balance as a motor ability with the performance of the major outer reap throw technique (according to the program of special physical education-SPE), for a possible modification of mentioned training technique and selection of appropriate resources to improve the same. The study was conducted on a sample of 67 male subjects. The sample of variables consisted of eight standard tests for the evaluation of the balance of motor ability, and the variable for assessing the level of adoption of the major outer reap throw technique from the SPE program. Analyzing the results, obtained by regression analysis, it was found that there was no statistically significant correlation between variables for balance assessment and the efficiency of major outer reap throw technique. Since the statistically significant correlation between applied test for the balance evaluation and the observed technique performance was not found, it seems necessary that in similar future studies specific and consistent tests, which more accurately explain the dependence between the balance and the quality of a major outer reap throw technique, should be constructed or selected.

Keywords: Balance, technique of performance, connectivity

INTRODUCTION

The technique of program contents of the SPE represents the system of rational movements and trends that are manifested in the current levels of adoption, such as typical movements, blocks, kicks, throws, sweeping and joint locks (Guzvica, 2006) whereby, among other abilities and characteristics, motor skills have great significance. Performing these techniques causes certain movements in space and time, with certain segments of the body changing its relative position, and therefore disturbs the balance. Sekulic & Metikos (2007) found that the balance is the ability of keeping the body in a certain position during inaction, but also the ability to quickly establish a stable position of the whole body in a variety of movements and trends. Nicin (2000) concludes that the balance is a basic motor ability to maintain the body in a balanced position (position) which depends on many factors, of which the most important are: genetic determinism, the state of the brain balance center, the condition of the vestibular apparatus, age, bearing surface, the height of the center of gravity of the body, the number of motor habits and training, etc. In mechanics, it is the balance positions which are classified according to the behavior of the body under the influence of forces that tend to change their position, while most of the human body position is maintained by active muscular forces (Jaric, 1997). Due to the fact that the balance is ability to preserve a stable position of the body in a variety of motion (movement) and position, that is the ability to retain the body in a given position, we distinguish between static and dynamic balance. Static balance refers to the maintenance of a specified position at a stand-still, where default position should be maintained by static stress (bearing surface is fixed) whereas dynamic balance implies the ability to maintain a stable body position that is in motion (activities in which fast changes in the position of the body in space are often carried out) during which it often comes to the change of the surface of the body support. Kosinac (2009) considers that a good balance requires good integrated nervous system with adequate afferent input, moving joints and healthy muscles, wherein the disorder of any of these factors reduces the ability to maintain the balance. According to him, sensory information have a key role in all movements, i.e. contractions of α-motoneurons, which means that they have a key role in posture. Activities of α-motoneurons can directly modify only the sensible signals from the peripheral receptors and command signals of the descending brain pathways. Precisely these sensing signals from the peripheral receptors belong to the control mechanisms of body posture, because the center of gravity is located in the cerebellum, where in turn it is necessary to maintain the balance of the vestibular somato- sensory system. This is important because information about the disrupted balance come from the vestibular apparatus to the cerebellum, where the actual program of correction is made, from which a quick response follows through adequate movements that aim to restore as soon as possible a stable balance position of the body, which means that sub-vestibular apparatus and the cerebellum are an important regulator of muscle tone (ibid). In the research that was conducted by Golab, 1962 (per Zaciorski), it was found that the static and dynamic balance with each other very little correlated. It was also established that, while maintaining a stable balance position, the human body is not absolutely motionless, but it is all the time, "balancing", and no matter that this movement is not characterized by the parameters of locomotion (amplitudes are very small and often unnoticed) it is conducted in the joints that are near the surface of the support. From this arises the need to differentiate the ability of maintaining its balance position according to the way of application of force, the manner of using the optic analyzer, and the size of the surface on which the balance is maintained. The stability of the body in the standby mode depends on the body weight, the force of muscles which maintain the stability, as well as the surface of the support, wherein the

technique performer is in a balance position as long as an external force which acts on it (torque header) is smaller than the moment of the gravitational force of one who attacks it (Kules, 2008). The dynamic indication of the stability of the balance position in one position is expressed by the angle formed by the angle of the safety which is formed by the projection of the general center of gravity of the body and the outer edge of the support surface, wherein the safety angle increases with the safety support surface and by lowering the general center of gravity (OCT). This leads us to the conclusion that the larger is the angle, the body is better balanced, which means that the techniques performer can preserve its balance until projection of OCT has travelled outside its supporting surface (Jaric, 1997).When realizing the movement and the movement characteristic of the program of SPE it is very important to emphasize that they begin and end in a stable balance, where the center of gravity of the body is above the surface of the support. However, due to not enough "strength" in the muscle and joint system, balancing is done mostly unknowingly with some compensatory movement and the important role of antagonist muscles. Of course, when the center of gravity of the body is located below the surface of the support, then there is no problem with balance, because the balance position is held by gravitational forces and without the active participation of muscles. Within the current program the Faculty of Security Science University of Banja Luka, as part of the SPE, to the level of utilitarianism, among other techniques, are taught throwing techniques of judo that in terms of biomechanical method of the embodiments can be divided into: throwing techniques by cleaning (de ashibarai and okuriashibarai), throwing techniques by outbreak (o sotogari and haraigoshi), throwing techniques by coverage (ipponseoinage, koshiguruma, ogoshi and morotegari) and throwing techniques by block (sasaetsuricomiashi and tai otoshi). In the SPE, throwing techniques are complex movement structures designed primarily for the destabilization and the infliction of the pain to the "opponent" on the way of establishing complete control over him. The techniques are usually performed in self-defense, as a technique to counter-attack (although they can be applied in direct attack). The efficiency of their realization depends on the timeliness of commencement, duration of the performance and the control before, during and after their implementation. The techniques are carried out after the capture of the opponent's body or parts of the opponent's body, by transferring its own motion to an opponent's body (Arlov, 2001). Drid (2005) states that during the mutual struggle in mutual attacks more successful is the one who is conversant with the technique, who knows to maintain so its own balance, while at the same time disrupts the opponent's balance and uses his errors when performing certain attacks or operations. It has already been mentioned that the success of throwing is determined by strength, speed, timing and accuracy, whereby it is very important that the position of his body is adjusted to the position of the opponent's body, to perform the throw by using the smallest possible energy power. Thus, the performance of the throw is done at high speed, whereby it is possible to single out the following phases: phase of upsetting the balance of the opponent, the phase of establishing contact with the opponent and the phase of implementation of the throw. All these phases are interrelated and form one unit, whereby the efficiency of their implementation dependent on precise and rapid (explosive) performance of all phases (Milosevic, 2013). Each of these phases is characterized by a specific movement (trajectories of individual body segments) with maximum mutual dependence. Distortion of your opponent's balance aims to create favorable conditions for carrying out an imaginary technique, where the most important thing is that the projection of the body center of gravity of the opponent is removed as much of the surface of the support center, which is usually performed in the movement by using the inertial force and the weight of it (pulling or pushing) and depends on the reaction and movement of it (ibid). Achieving the contact with an opponent can be performed in all these directions, where the performance

technique requires quick implementation so the opponent would not return to the balance position. According to the first principle the throwing is performed by rotating the body of performer around the point of blocking (foot, lower leg, knee, thigh and hips), and according to the second, by turning the performer's body through a balanced oppositely to the direction of the force. Thus, it should be noted that if the arm torque is higher or the turnstile is lower, the torque rotation will be higher, because the attacker's force is increased by the component of gravity. For the efficiency of the performance of techniques of throwing with outbreak of the stein leg it is essential that the opponent's center of gravity projection falls in point of support, thus the possibility of its resistance reduced to the passive static resistance (ibid). From the above we see that the efficiency of throws in the first instance depends on the instability of the opponent's balance and correctly carried out the preparatory movements for pitching (which requires a stable balance position of the performer) which requires clarification of the importance of the balance in the application of the outer reap throw technique in the SPE program. The reason why this technique has its own respective application in the SPE program is that the initial phase of the throw-off pushing the opponent backwards, wherein the direct and quick entry into this roll allows the body weight of the performer to be transmitted to the opponent's why he loses the balance because there is no visual contact with the direction in which he moves, and it is therefore more difficult to re-establish the position of stable balance and organize the defense. Like almost all other throwing techniques and the technique of the outer reap throw is characterized by three stages: the stage of disrupting the balance of the opponent, the phase of the establishment of the contact with the opponent and the phase of the pitch. All these phases are interrelated and form one unit, with the efficiency of their implementation dependent upon precise and rapid (explosive) performance of all the phases (ibid). Each of these phases is characterized by a specific movement (trajectories of individual body segments) with maximum mutual dependence. The throw is taken from the basic attitude and right guard at the moment when the opponent pulls or pushes (in our case, when the opponent pulls toward you), so as to step right foot backwards withdrawing the performer to himself disturbing his balance. At the time of the balance disturbance the performer reflex action tries to maintain a stable balance by carrying out a step with the left foot forward into the left side for about 15 to 20 cm from the opponent's right foot, which is fully transferred weight to the left leg and stabilize the balance position. In the following activities the performer simultaneously pulls the left hand of the opponent's right hand toward the belt and pushes the right hand of the opponent's left shoulder and the left side of the body to the left, and thus disturbs the balance of the opponent. Furthermore, by strong twisting of the body in the outside in the angle of 45 degrees (continuous contact with the opponent) on the opponent leads to no balance position, reducing its surface support (causing him to stand on the outside of the right foot). Further action is by rotating the pelvis to the left the performer performs swinging right foot forward (behind the opponent's right leg, so that the head and the fingers of his right leg in the same plane), followed by simultaneously bending the body forward and downward, strong momentum of the same (by half) back foot makes contact in the crook of the knee of the opponent's right leg, knocking his leg back and up. The performer by synchronizing and powerful dragging of his left hand to her right hand and pushing down throws the opponent in front of him (directing him, while so that he falls on the left side of the body surface). It is very important that at the outbreak of the opponent's leg the performer maintains the stable balance. This is achieved in the way that the entire weight of the body transfers to the front of the foot of the stein leg, which allows him to fully control the opponent’s decline to the ground. Experience has shown that, in these circumstances it is very complex and important for learning and adoption of motor programs

from SPE to maintain a stable balance position, and that is why the balance is the subject of our research. In this regard, the goal of the research is to investigate the relation of balance as the motor ability with the performance of major outer reaps throw technique from the SPE program, for a possible modification of that training technique and selecting appropriate resources to improve the same.

METHODS

Overall education of outer reap throwing technique lasted six teacher's hours during three weeks, and was accomplished during the ordinary classes with the first-year students of The Faculty of security science during the second semester in the cabinet of martial arts of the Faculty of Physical education and sport in Banja Luka. The efficiency of performing the outer reap throwing technique was determined by an expert evaluation by five examiners (experts for SPE). Techniques were performed three times each, where subjects were turned sideways in relation to the testers. Application of the evaluation required a certain preparation of evaluators for the evaluation, in which evaluators, in order to harmonize the criteria of assessment, a film was shown for the presentation of outer reap throw techniques of the stein leg from behind and shown a diagram with certain stages that needed particular attention: getting out of balance, the establishment of the contact, entering the appropriate position for throwing and throwing performance.

The sample consisted of sixty-seven students (67) of the first year of the Faculty of Security Science in Banja Luka, male. The subject represented a population of physically active persons, aged 19 ± 0.6 years, clinically healthy, with no visible physical defects or morphological abnormalities. Basic antropomorphological indicators of the tested samples were as follows: TV = 181,40 ± 5,90 cm, TM 78,60 ± 10,18 kg i BMI 23,87 ± 2,51. The sample of variables in this study is divided into the predictor variables and the criterion variable. Sample predictor variables consisted of a set from8 tested in practice-implemented variables to assess the capability of maintaining a balance: MBAU20 (standing on two legs longitudinally on the bench for balance with eyes open), MBAU10 (standing on one leg longitudinally on the bench for balance with eyes open) MBAP20 (standing on two legs cross on the bench for balance with eyes open), MBAP10 (standing on one foot cross on the bench for balance with eyes open), MBAU2Z (standing on two legs longitudinally on the bench for balance with your eyes closed), MBAU1Z (standing on one leg longitudinally on the bench for balance with your eyes closed), MBAP2Z (standing on two legs cross on the bench for balance with your eyes closed), MBAP1Z (standing on one foot cross on the bench for balance with your eyes closed). All variables to assess motor skills - balance possess the necessary metric characteristics (Metikos, Hofman, Prot, Pintar & Oreb, 1989).

The criterion variable was the assessment on taking the outer reap throw, and was formed by the average score of the five experts who teach SPE-e in a scale of 5.00 to 10.00. The criterion of evaluation was as follows:

The rating of 10 (ten) was assigned for perfect constructive throwing technique, in the optimal rhythm, which satisfies the basic principles of biomechanics and enables a safe and complete control.

Rating 9 (nine) was assigned for excellent performance techniques or correct, without any technical errors, constructive technique, with adequate power, speed and amplitude throws performed.

Rating 8 (eight) was assigned for the throw that, technically, it's not entirely true implemented or not implemented strongly, fast enough, the opponent did not have sufficient amplitude of

fall, or if the performer made a mistake in the correct performance of techniques, as an insufficient ejection of the opponent off balance or improper contact with the body of an opponent.

Grade 7 (seven) was assigned to toss that was carried out by at least two errors or if the throw was performed with insufficient amplitude or that they were not truly and well performed two of the three phases of the throw: getting out of balance, making contact with an opponent and the final phase of the throw.

Ratings of 6 (six) was assigned for the throw, with the apparent faults in the art embodiment. By this is meant the apparent lack of or incorrect performance of one of the first two phases throws (pull-out of balance and making contact) and the lack or incorrect performance of a segment of the throw. This means that throwing is not carried out by an adequate force and speed, and has the necessary amplitude of the fall, but there are at least two phases of the throw, and as such can be recognized.

Rating 5 (five) was assigned to toss that do not fully meet the basic technical characteristics of the respective throws. Throwing is not done fast and strong enough; neither opponent has the necessary amplitude of the fall. At the same time, the correct throwing out two out of three phases of throws (or are badly implemented).

All data were analyzed by methods of descriptive and comparative statistics. From the field of descriptive statistics, for each variable measures of central tendency (arithmetic average) and measures of dispersion (standard deviation) were calculated, whereas the test for normal distribution of the results applied Kolmogorov - Smirnov test. To determine the qualitative correlation between predictor and criterion variable regression analysis was applied. All statistical calculations were performed using SPSS statistical software application (version 20.00).

RESULTS

Table 1. Descriptive indicators of predictor variables and the criterion variable

Variables	N	Mean	Std. Deviation	KS (p)
MBAU20	67	3.43	1.76	.19
MBAU10	67	11.67	10.48	.27
MBAP20	67	6.14	5.77	.29
MBAP10	67	4.05	3.17	.31
MBAU2Z	67	2.53	1.32	.23
MBAU1Z	67	2.97	1.03	.25
MBAP2Z	67	2.37	.79	.29
MBAP1Z	67	2.00	.71	.20

TBINOT	67	6.82	1.02	.45

Legend:N - number of respondents; **Mean** - mean; **Std. Deviation** - standard deviation; **KS(p)** - Kolmogorov-Smirnov test of probability; **MBAU20** - standing on two legs longitudinally on the bench for balance with open eyes, **MBAU10** - standing on one leg longitudinally on the bench for balance with open eyes, **MBAP20** - standing on two legs cross on the bench for balance with open eyes, **MBAP10** - standing on one leg cross on the bench for balance with open eyes, **MBAU2Z**- standing on two legs longitudinally on the bench for balance with your eyes closed, **MBAU1Z** - standing on one leg longitudinally on the bench for balance with your eyes closed, **MBAP2Z** - standing on two legs cross on the bench to balance with your eyes closed, **MBAP1Z** - standing on one leg cross on the bench for balance with your eyes closed, **TBINOT** - throwing technique with the outbreak of legs from behind.

Table 1 shows the descriptive statistics of the measures used to assess balance motor skills, as well as measures which evaluated the efficiency of the technique of the outer reap throwing technique. Table 1. The results of Kolmogorov-Smirnov test match the normality schedule of the results. Average evaluation of efficiency of a outer reap throwing technique is 6.82.

Tables 2 and 3 show the relationship between the dependent variable throw discharge stein rear legs (TBINOT) and the associated independent variables for the evaluation of motor abilities balance.

Table 2 Parameters of multiple regressions of motor skills balance for variable TBINOT

R	R^2	The standard error of assessment	F	p
.351[a]	.123	1.028	1.017	.434

a Predictors (Constans) MBAU2O, MBAU1O, MBAP2O, MBAP1O,MBAU2Z, MBAU1Z, MBAP2Z, MBAP1Z
b Dependent varijable TBINOT

Table 3 The regression coefficients motor skills balance for variable TBINOT

Model		Non-standardized coefficients		standardized coefficients	t	p
		B	The standard error	Beta		
1	(Constant)	6.344	.616		10.304	.000
	MBAU20	-.070	.078	-.120	-.904	.370
	MBAU10	.005	.013	.053	.363	.718
	MBAP20	.012	.026	.068	.473	.638

MBAP10	-.110	.056	-.340	-1.961	.055
MBAU2Z	.037	.123	.047	.298	.767
MBAU1Z	.268	.154	.270	1.739	.087
MBAP2Z	-.110	.191	-.085	-.576	.567
MBAP1Z	.205	.236	.142	.869	.388

a. Dependent Variable: TBINOT

B - Beta coefficient; Std. Error - standard error; t - t test; p - statistical significance; MBAU20 - standing on two legs longitudinally on the bench for balance with open eyes, MBAU10 - standing on one leg longitudinally on the bench for balance with open eyes, MBAP20 - standing on two legs cross on the bench for balance with open eyes, MBAP10 - standing on one foot cross on the bench for balance with open eyes, MBAU2Z¬- standing on two legs longitudinally on the bench for balance with your eyes closed, MBAU1Z - standing on one leg longitudinally on the bench for balance with your eyes closed, MBAP2Z - standing on two feet cross on the bench for balance with your eyes closed, MBAP1Z - standing on one foot cross on the bench for balance with your eyes closed, TBINOT - throwing technique outbreak legs from behind.

The results of the regression analyze shown in Table 2 show that there is no statistically significant qualitative relationship between the predictor and criterion variable which results in inability of the prediction of the result of outer reap throw technique according to the motoric balance ability.**.** Multiple correlation coefficient indicates a small approval of the dependent variable with independent variables, while the coefficient of multiple determination explains 12.3% of common variability with the criterion, whereby the value of the F-test and the achieved level of significance ($p = 0.434$), indicates the absence of predictive influence on it . The remaining 87.7% in explaining common variability can be attributed to some other anthropological characteristics and abilities that were not the subject of this research.

Table 3 shows the values of beta coefficients that provide information on the impact of individual tests for assessing motor skills balance the effectiveness of a technique of outer reap throwing stein legs.. The table shows that no single variable has no statistically significant effect on the efficiency of a technique of outer reap throwing stein from the SPE program .On the border of statistical significance (0.055) there is a variable standing on one foot cross on the bench for balance with open eyes (MBAP1O), the coefficient Beta is - 0.34, which means that this variable alone contributes most to explaining the dependent variable, when deducting The variance explained by any other variable in the model. A little smaller contribution is made variable standing on one leg longitudinally on the bench for balance with your eyes closed (MBAU1Z), the coefficient beta is 0.270, which is also close to statistical significance (0.087), while the other variables are not made a unique contribution to the prediction of dependent variable, which may be the consequence of their mutual overlapping.

DISCUSSION

Average evaluation of an outer reap throwing technique is 6.82. The reason for this achievement of construction techniques can be found in a relatively small number of hours of

training, which is why students were not able to carry out the optimum number of its repetition. The available number of hours not only that they did not provide for the adoption of outward form of a technique, but also the acquisition of the inner form that includes the optimum dynamics and kinematics given criteria provided for its implementation. Furthermore, if one takes into account the complexity of the observed techniques, and its specification motor and other skills, such results is somehow expected because it comes to a complex technique that requires a high level of mobility as well as cognitive abilities. This is supported by the research that was conducted by Radjo (2001), in which he balances out as the dominant motor skills in performing outer reap throwing (o soto gari), especially at the stage of standing on one leg and the other leg sweeping. Further, he claims that in addition to motor skills (balance) cognitive processing is the most associated with the quality of performing these techniques. So, based on practical experience and previous research, we can conclude that for the effective implementation of these techniques the coordinated action of man as an integrated biological system is required (it is necessary to achieve the level of automation), which by given time available for training and previous experience of the most examinees is not objectively possible. For the results obtained by regression analysis explanation can be found in the kinematics and dynamics of the performance of observed throwing techniques. Namely, the outer reap throwing technique is carried out in accordance with the principles of biomechanics, the maximum speed and optimum level of force, wherein the segments related to certain parts of the body change .Changing the position of the parts of the body affects the change in the position of balance during which the displacement of the center of gravity of the body and the reduction of support area increased requirements for balance maintenance occurs, in which the performer must control the body position of the opponent during the fall after realized throw as well as maintaining his own balance. Because of the kinematics and dynamics of the major outer reap throw technique there is an imbalance of the body, especially in the second phase of construction where fast compensatory movements of the body and head forward are made, where the performer is on one leg (reduced bearing surface) so that his body weight is transferred to the stein leg. At this stage of the performance, there is increased requirement for balance, which is based on a system of inter-reactions of the body that are responsible for the spatial orientation of the body. For all run-time techniques of coordination and integration of information from muscles, tendons and joints reach the motor cortex and cerebellum, almost instantaneously the correction in the balance is done until they are fully stabilized. Unfortunately, in our case, using selected tests of evaluation there is the static balance for which the system that includes information from joints and vibration sensors that provide information about the position of the body at rest is largely responsible, and it is therefore understandable that we did not receive a significant effect of the balance performance on the major outer reap throw technique. Another possible reason is, above all, lack of time for training, so that we reached a relatively low level of acquisition techniques, which made a full connection of strength and coordination of the individual parts of the body of our students. Similar results were gained by Gužvica (2008) exploring the association of balance with the level of performance techniques strokes forehead fist in karate, where he found that the static and dynamic balance with each other do not correlate. Further comparing the results of this study with the results of other studies in which the balance as motor ability is researched (Metikos et al., 1989) and its significance as part of the factor structure of success in judo (Sertic 2004; Paillard, Montoyai, Dupui, 2007; Cousin, Nurkic & Cicovic 2014). And we have obtained almost identical results.

CONCLUSION

On a sample of 67 male subjects aged 19 ± 0.6 years, the influence of balance motor ability on the efficiency of major outer reap throw technique was examined. Applied parametric statistics showed that, based on the tests with which the balance was analyzed as a significant factor for the motor programs performance, the balance as a motor ability did not appear significant for carrying out the major outer reap throw technique. Regression analysis also showed that there was no statistically significant correlation between administered tests with the quality of mentioned technique performance respectively, which indicates that in similar future studies specific tests should be constructed or selected. These specific tests would more accurately explain the dependence between the balance and the quality of the performance of major outer reaps throw technique. The assumption is that these specific tests could be helpful, not only to facilitate quicker and easier adoption of SPE training programs, but also to make them more efficient. It is considered that these tests would be of great help in the selection of candidates for admission to the Faculty of Security Science.

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SUMMARY

The aim of the research is to determine the relation of balance as a motor ability with the performance of the major outer reap throw technique (according to the program of special physical education-SPE), for a possible modification of mentioned training technique and selection of appropriate resources to improve the same. The study was conducted on a sample of 67 male subjects. The sample of variables consisted of eight standard tests for the evaluation of the balance of motor ability, and the variable for assessing the level of adoption of the major outer reap throw technique from the SPE program. Analyzing the results, obtained by regression analysis, it was found that there was no statistically significant correlation between variables for balance assessment and the efficiency of major outer reap throw technique. Since the statistically significant correlation between applied test for the balance evaluation and the observed technique performance was not found, it seems necessary that in similar future studies specific and consistent tests, which more accurately explain the dependence between the balance and the quality of a major outer reap throw technique, should be constructed or selected.

Keywords: Balance, technique of performance, connectivity

THE EFFECTIVENESS OF VARIOUS TEACHING APPROACHES ON THE PERFORMANCE OF THE VOLLEYBALL GAME

EFIKASNOST RAZNIH NASTAVNIH PRISTUPA NA UČINAK U ODBOJKAŠKOJ UTAKMICI

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SUMMARY

The aim of the study was to determine and verify the effectiveness of various teaching approaches on changes in the level of volleyball performance in the process of teaching volleyball to pupils in primary schools. In the experimental group was used the tactical approach and in the control group the techniques (traditional) approach in teaching of volleyball. The experimental group consisted of 26 pupils and the control group consisted same number of pupils. Both groups, representing 13 to 14 year old schoolgirls in primary school. Efficiency of the teaching approaches was evaluated based of game performance. Game performance was evaluated by the method of game performance assessment based on GPAI (Game Performance Assessment Instrument) through video record. To perform statistical evaluation Mann-Whitney U-test was used. When we evaluate the tactical component of game performance "position", we found out that the difference between groups is not statistically significant ($p > 0.05$). By comparison "decision-making" it was discovered that the difference, between achieved performances in groups it is statistically significant ($p < 0.05$) in favour of the experimental group. By comparison skills execution we found out, that the difference between both groups in "serving" is not statistically significant ($p > 0.05$). But by comparison of passing, setting, offensive hit and team's game performance" we found out statistically significant ($p < 0.05$) the difference between both groups in favour of the experimental group. The acquired data pointed to the fact that in generally the tactical teaching approach appears to be a more efficient method for acquiring game skills and tactical components of the game.

Key words: *volleyball, teaching approaches, performance*

INTRODUCTION

Nowadays the quality of the learning process is one of the main reasons why children in primary and high schools are not interested in physical activities. Another reason being inadequately prepared teachers who are not able to motivate pupils towards physical activities by means of didactic styles and teaching approaches. The thematic unit of sports games (traditional, non-traditional) are amongst the most popular sports activities of physical and sports education in school with the largest number of hours in the annual schedule.

According to several authors (Zapletalová, Přidal, Laurenčík, 2007; Popelka, 2013), the problem of the didactic process with every sports game and thus also with respect to volleyball is that this process teaches the pupils to play as quickly and effectively as possible, which means to reach a continual game manifestation and to awake in students a lasting interest in the game. This can be achieved by means of optimal teaching approaches amongst which are teaching methods, organisational forms, teaching processes, teacher interaction (Popelka, 2012a). Several authors (Thorpe, Bunker, & Almond 1986; Psotta, & Velenský, 2001; Dobrý, 2003) found that the past and present didactics and practices have been using various teaching approaches in teaching of sports games. Both in the past and present in our system of teaching of sports games used the so called technical teaching approach, which is mainly focused on practicing individual's game activities and game combinations and only after their partial managing can pupils play the game itself. This model is criticized by several authors (Zaťková, 2003; Lukavská, 2006) who, when evaluating the teaching process in sports games, point to the fact that pupils have strong limitations in game competence. English speaking countries mainly use tactical approach in teaching sports games, which is based on pupils being encouraged to understand all aspects of the game with a concurrent increase of physical performance, motivation and enjoyment in physical education (Popelka, 2012b). This model is known as Teaching Games for Understanding, created by Bunker and Thorpe.

Authors Alison and Thorpe (1997) and Blomqvist, Luhtanen, & Laakso (2001) claim that by using the tactical approach in teaching sports games, the pupils acquired tactical knowledge, game skills and understood all aspects of the game, whereas the pupils educated by traditional technical approach improved only their game skills. According to Popelka (2013), the main argument for using this model when teaching is to increase the motivation of pupils to participate in compulsory physical and sports education. Another research authors (Turner, & Martinek, 1992; Rink, 1996) compared both approaches in teaching of sports games, did not discover any significant differences of the previously mentioned teaching approaches. Their research works coincide with the fact that pupils who participated in the tactical teaching approach expressed more joy and showed the same improvement in technique as well as in the game itself. When comparing the specific knowledge, neither Olosová nor Zapletalová (2014) confirmed stronger effectiveness of tactical teaching model in comparison with the technical model. Several authors dealt with the comparison of both models (Řezničková, & Zapletalová, 2014; Popelka, & Pavlović, 2015; Žuffová, & Zapletalová, 2015) and our article is also aimed at empirical verification and comparison of the educational effects of technical and tactical teaching approaches on volleyball performance of pupils in primary schools.

The aim of this research was to compare the effectiveness of various teaching approaches on volleyball performance of pupils in primary schools.

METHODS

In our research, we used a pedagogical experiment with two groups, representing 13 to 14 year old schoolgirls in primary school. The research took place in January 2016 until March 2016. The experimental group consisted of 26 pupils and the control group consisted same number of pupils. The research was conducted on 17 classes, of which both groups are trained 15 classes in volleyball. The first and last classes were designed to evaluate game performance.

During 8 weeks of the intervention experimental group was taught by the tactical teaching approach and control group by the technical teaching approach twice a week for 45 minutes in volleyball classes.

Teaching with tactical approach: The main part of the class started with a modified game. After the modified game, there was a discussion where the teacher asked the student questions. The pupils tried to find answers to the questions. Then the teacher chose other modified games. Pupils played the most frequently modified games 2 vs. 2, 3 vs. 3, 4 vs. 4, 5 vs. 5, 6 vs. 6 games and least did technical exercises.

Teaching with technical approach: Every main part of the class began with the practice of the technique. Prior to training, the teacher explained the technique of skill, tactical use in the game and then followed by a match. The technical approach to teaching was dominated by practice techniques, 6 vs. 6 games and the least modified 3 vs. 3.

Comparison of the use of the specifics tactical and technical approaches are reported in Table 1.

Table 1 Comparison of the use of the specifics of teaching approaches

Teaching approach	Group	The specifics of teaching							
		Techniques exercises	Modified games	Official game	Didactic styles				
					1	2	3	4	5
Tactical approach	**Experimental group**	6,70%	73,3%	20%	11,8%	0%	35,3%	71%	64,7%
Technical approach	**Control group**	46,7%	13,3%	40%	58,8%	24%	0%	0%	41,2%

Notes: 1 - didactic style command, 2 - didactic style practical, 3 - didactic style with offer, 4 - didactic style with controlled discovery, 5 - didactic style with individual discovery

Note: The percentage of use of didactic styles represents the real number of use of teaching specifics in the classes (we used several didactic styles in one class)

In this article, we present the information containing output level of the game performance in volleyball of the pupils in experimental and control group. We used the method of observation for planned and deliberate observation of the quantity and quality course of tactical and technical game components to obtain the data. Game performance components were analyzed using audiovisual equipment. The selection of evaluated game components and criteria of their evaluation were based on the evaluation of game performance according to Mitchell, Oslin, & Griffin (2006). Game performance evaluation took place at the last class, where each pupil played 20 minutes. The ability of decision-making, position and skill execution was evaluated.

Game components and criteria:

- **Decision-making:** The pupil uses the correct skill at the correct time.
  Scoring Key: Appropriate: The pupil uses the correct skill at the correct time (forearm pass on 1st touch; overhead volley on 2nd touch; hitting action on 3rd touch). Inappropriate: The pupil do not uses the correct skill at the correct time (hitting action on 2rd touch)
- **Position:** After hitting the ball, the pupil will take the appropriate position in the court.Scoring Key: Appropriate - after hitting the ball, the pupil will take appropriate position in order to have optimal coverage of the course. Inappropriate - after hitting the ball, the pupil does not will take appropriate position in order to have optimal coverage of the course.
- **Skill Execution:** The student passes the ball accurately (ball reaches the intended target) Scoring Key:

Setting, passing

Effective - The pupil hit the ball in accordance with the rules, technically correct, and sett, pass the ball to the teammate. Inefficient - The s pupil does not hit the ball in accordance with the rules, technically wrong, and does not sett or pass the ball towards to the teammate.

Offensive hit

Effective - The pupil hit the ball in accordance with the rules and technically correct.Inefficient - The pupil does not hit the ball in accordance with the rules and technically correct.

Serving

Effective - The pupil serve the ball in accordance with the rules and technically correct.
Inefficient - The pupil does not serve the ball in accordance with the rules and technically correct.

For the evaluation of results, we used Mann-Whitney U test for independent selections and descriptive statistics. Significance was determined on standardly used 5 % level ($p<0.05$).

RESULTS

The comparison of game performance of the team in experimental and control group is presented in Table 2.

Table 2 The comparison of output evaluation of control and experimental group's game performance

Comparison of the groups	D	P	Se	Pa	Set	Oh	TGP
Eg	73.30%	74%	67.50%	70.20%	68.30%	70.10%	71.40%
Cg	62.10%	65.20%	60.30%	53%	50%	52.80%	57.20%
M-W	0.010	0.132	0.147	0.025	0.014	0.017	0.001

Explanatory notes: Eg – experimental group, Cg – control group, M-W – Mann Whitney U test $p < 0.05$, D – decision about "what?" to do, P – position after the hitting, Se – serving, Pa – passing, Set – setting, Oh – offensive hit, TGP – team's game performance

By comparing decision-making it was discovered that the difference, between achieved performances in groups is 11.2% in favour of the experimental group, it is statistically significant ($p< 0.05$). Therefore, we can claim that the experimental group was significantly better in the evaluation of this tactical game component about "what" will the pupil demonstrate. Considering the aforementioned facts, we state that pupils in the experimental group demonstrated better ability to make a right decision in various game situations. We assume that the pupils acquired this ability due to the amount of modified games in which they also had to fulfil tactical tasks.

By comparing the performances in the position, we discovered 8.8% difference between the groups in favour of the experimental group. Despite the fact that the tactical teaching approach was used by the experimental group, in this case the difference between groups is not statistically significant ($p>0.05$). We assumed that the pupils in the experimental group would achieve statistically significant differences in comparison with the control group, whereas the pupils in the experimental group had more opportunities for solving the aspect of this tactical game due to the fact they played modified games. In such games the teacher asked a question such as: "What part of the court should you stand/take position after hitting the ball?" which in this case lead to choosing the right position on court after hitting the ball.

The difference in serving between the groups was 7.2% in favour of the experimental one. Such a difference is not statistically significant ($p>0.05$). We assume that the experimental stimulus did not significantly influence the learning and improvement of serving, because pupils served on shorter distance more often. Despite the fact that serving did not show statistically significant differences, we think that the ability to cope with the stress during the game is an important requirement for success. We assumed that the experimental group, which played a variety of modified games, can better cope with the stress and pupils would ultimately play better as individuals.

By comparison the passing between the groups was a difference of 17.2% in favour of the experimental group, which is statistically significant ($p<0.05$). Based on the achieved performances in passing, we assume that experimental stimulus influenced this defensive game activity in a more positive manner. We want to highlight the level of mastering this game activity of the individual is very low in the control group. If the players can not properly pass to one another, on such level of performance it is difficult for a setter to pass the ball for a spike.

By comparison the setting between the groups a difference of 18.3% in favour of the experimental group, which is statistically significant ($p<0.05$). We assume that the game performance of settings in the control group was significantly influenced by the previous game activity - passing. We suppose that if the passing was better, the control group would achieve better performances in setting and attacking.

By comparison the offensive hit between the groups a difference of 17.3% in favour of the experimental group, which is statistically significant ($p< 0.05$). We assume that the amount of matches with fewer players enabled the pupils in the experimental group to be more frequently in contact with the ball in the offensive phase and subsequently to achieve successful offensive hits.

By evaluating the team's game performance a difference of 14.2% in favour of the experimental group. This difference is statistically significant ($p<0.05$). The Volleyball game is characterised by an individual's previous game activity of the individual influences over the next one. This was also confirmed by our research. Whereas the passes and sets in the experimental group had a success rate of approximately 70% and so the offensive hit with a 70.10% rate of success. All the game activities of the individual in the control group were just above 50% and therefore the success rate of the offensive hit was also only 52.8%. From the achieved results we can state that from an statistical significance point of view the experimental group was better only in one tactical game component "decision-making". We were surprised that in the second tactical component "position" the experimental group did not achieve better results in comparison with the control group. On the other hand, by the evaluation of this tactical component of the experimental group achieved a 8.8% better performance.

DISCUSSION

Several authors (Alison, & Thorpe, 1997; Blomqvist, Luhtanen, & Laakso, 2001) discovered that by means of a tactical approach, in comparison with the traditional learning, pupils are able to deepen their tactical thinking and ability to make the right decisions during their games. This claim was statistically significant ($p<0.05$) proved by our research as the evaluation of the tactical component of the games performance "decision-making"). This means that pupils in the experimental group were able to make a better decision about "what" they should do and "how to do it" (to choose a technique). However, they were not better in choosing the right position on the court after hitting the ball although the difference expressed as a percentage is in favour with the experimental group. We think that the pupils in the experimental group were able to make a better decisions based on the variety of modified games they played 2 vs. 2, 3 vs. 3, in which the technical requirements (Light, 2010) are reduced so that all pupils can take part in the game. At the same time the emphasis was placed on the game tactics and the

development of the physical skills. We agree with (Psotta, 2002) that modified games support pupils' cognitive activity and require the use of appropriate teaching didactic styles. That is why we used in our research different didactic styles in teaching, which overlap the cognitive threshold. For example, after the modified game, there was a discussion where the teacher asked the pupils questions. The pupils tried to find answers to the questions. These didactic styles are regarded as the decisive aspects of education by Webb, Pearson and Forrest (2009). According to Griffin, Mitchell & Oslin (1997), the performance depends on making tactical decisions, i.e. the ability to identify the problem and find the solution in the given game situation. Based on our observation of evaluation of the level of game performance we can conclude that, in general, experimental group taught through the tactical teaching approach, reached statistically significant ($p < 0.05$) better quality of game performance than the control groups. In the past Kuchárik (2014) provides similar results in mini handball and Žuffová (2012) in frisbee ultimate. After the evaluation of both groups in individual game activities, the statistically significant ($p< 0.05$) differences in technique of passing and setting were confirmed in favour of the experimental group. Some authors (Fraňo, 1994; Zapletalová, Čabajová, 2001) state, that the analytical-synthetic method preferred in technical approach is more effective in learning and improving offensive hit. In our research this claim was not confirmed, because by comparison of offensive hit we found out statistically significant ($p < 0.05$) the difference between both groups in favour of the experimental group. We think that many modified games allowed the experimental group to get better in offensive hit, because all pupils are often in contact with the ball and can take part in real game situation. Statistically significant difference between both groups was not identified only when serving and therefore we can state the same level of mastering this technique in both groups. These groups have in common that they were the most successful in serving. This can be explained by the fact that serving is a unique activity in volleyball, performed under the standard conditions (Hančík, Mašlejová, & Tokár, 1994; Zapletalová, & Přidal, 1996), i.e. serving is not influenced by the quality of the previous gaming activity. We realize that the number of respondents is small and the results can't be generalized. Another research authors (Turner, & Martinek, 1992; Rink, 1996) compared both approaches in teaching of sports games, did not discover any significant differences of the previously mentioned teaching approaches.

CONCLUSION

Our results represent only a part of the issue in comparing the effectiveness of various teaching approaches on pupils' game performance in primary schools. From an educational features point of view we used mainly modified games with fewer players (2 vs. 2, 3 vs. 3) in which we primarily used didactic styles in controlled discovery, didactic style with its individual discovery and didactic style with offer. In our case, the research pointed to this from a complex point of view, the tactical teaching approach appears to be most suitable method of learning game skills and tactical game components. According to the presented results, we can recommend the conclusions for practice:

- use of exercises, based on situational context of the game,
- use of several various didactic styles in one class.

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SAŽETAK

Cilj ovog istraživanja je bio da se odredi i potvrdi efikasnost raznih nastavnih pristupa na promjene u nivou učinka u procesu držanja nastave iz odbojke učenicima u osnovnim školama. U eksperimentalnoj grupi je korišten taktički pristup, a u kontrolnoj grupi tehnički (tradicionalni) pristup u nastavi odbojke. Eksperimentalna grupa se sastojala od 26 učenika a kontrolna grupa od istog broja učenika. Obje grupe su predstavljale djevojčice koje pohađaju osnovnu školu uzrasta, 13-14 godina. Efikasnost nastavnog pristupa je procijenjena na osnovu učinka u igri. Učinak u igri je procijenjen metodom procjene učinka u igri, baziranog na GPAI (instrument za procjenu učinka u igri) kroz video zapise. Mann-Whitney U-test je korišten da se izvrši statistička procjena. Kada se procjenila taktička komponenta učinka igre "pozicija", dolazi se do zaključka da razlika između grupa nije statistički značajna ($p>0.05$). Poređenjem komponente "donošenje odluke" otkriveno je da razlika između postignutih učinaka u grupama statistički značajna ($p<0.05$) u korist eksperimentalne grupe. U poređenju vještina izvršenja saznalo se da razlika između obje grupe u komponenti "serviranje" nije statistički značajna ($p>0.05$). Ali poređenjem dodavanja, smečovanja, ofanzivnog udarca i učinka u igri tima dobila se statistički značajna ($p<0.05$) razlika između obje grupe u korist eksperimentalne grupe. Prikupljeni podaci ukazuju na činjenicu da se, u ovom istraživanju, taktički pristup pokazao kao efikasniji metod za sticanje vještina igre i taktičkih komponenti igre.

Ključne riječi: *odbojka, nastavni pristupi, učinak*

PREDICTION OF RUNNING SPEED IN GIRLS ON THE BASIS OF STRENGTH

PREDIKCIJA BRZINE TRČANJA DEVOJČICA NA OSNOVU SNAGE

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SUMMARY

The aim of this study was to examine connection between the motor ability strength and the achievement of results in sprinting in order to define strength tests to perform selection in physical education classes, at the age of early puberty. The sample consisted of 88 female subjects aged 12 years (± 6 months). The batery of four tests was used for evaluation of the motor ability strength, prescribed in the curriculum for the subject Physical Education of the Pedagogical Association of Vojvodina: variables of explosive strength - standing broad jump (cm), throwing medicine ball from lying position (m), variable of repetitive strength - sit-ups (number of successful attempts) and variable of isometric strength - bent arm hang (s). For evaluation of the motor ability speed, the standardized test was applied, which represented the criterion variable - the result obtained in 60 m run (s). The relationship between the system of predictor variables and the criterion variable is calculated by linear regression analysis, and the results showed that, on the basis of the results of the predictor variables system, the level of sprinting speed can be statistically significantly predicted. By observing the individual variables, it can be seen that the variables standing broad jump (p=0.00) and sit-ups (p=0.00) achieve statistically significant prediction of 60 m run speed. By analyzing the results of regression analysis, it can be assumed that the result of the 60 m run in selected subjects can be predicted based on manifestation of explosive leg strength and repetitive strength of torso.

Key words: *sprint speed, strength, girls, explosive strength, repetitive strength.*

INTRODUCTION

Running is a natural form of movement and the basis of every exercise which is the foundation of many sports (Findak & Mraković, 2003). In addition to being a basis of every movement and many sports, it can be said that running has a very significant impact on overall health if practiced in natural and healthy conditions (Janković, 1998). Running is defined in the central nervous system, and its efficiency and speed depend on a number of inherent functions (Babić & Čoh, 2010). It is believed that functional and motor abilities are among the most responsible for success in short distance running (Homenkov 1977, Milanović 2007, Mihajlović & Tončev, 2008), and good technique, speed of alternative movements, explosive strength and maximum force of attempted movements are considered the most important factors in achieving high results on short tracks. The maximum speed that a human can manifest in any motion depends on a variety of factors which are related to morphological and physiological characteristics, energy mechanisms, gender, age, biomotor abilities, inter- and intramuscular coordination and optimal biomechanics of movement techniques (Čoh & Bošnjak, 2010). When talking about running for children, it referes to "natural biological development of sprint speed" (Babić & Čoh, 2010) that are most influenced by body height and weight, development of motor abilities and formation of motor stereotypes. Success of a child in sprinting disciplines depends, inter alia, on the period when the child begins to train - it is desirable that the child starts speed training before puberty, because this period is characterized by a balanced and proportionate development, and functional maturation (Bompa, 2000). Since the sprint type speed is a very important ability which causes success of an athlete in a number of situations during their sports career (Babić & Čoh, 2010), this paper will be focused on that activity. Sprinting is the fastest form of natural movement of human and it consists of repeating racing steps (Ibid.), more precisely, it represents a series of explosive jumps incorporated into a single coherent whole, whose basic task is to achieve maximum running speed as fast as possible and to preserve the achieved speed as long as possible (Marinković, 1977). In quick terminal sprint type movements, the development of force is a crucial factor in the efficiency of the movement, in which the variables of motor programme are the maximum force of agonist muscles, maximum force of antagonist muscles, delay time of antagonist muscles, time to reach maximum force of antagonist muscles, coactivation of muscles in the function of the position of kinetic chain, length of the movement, terminal position, starting position, duration of the movement and movement speed (Ilić, 1999). Since faster movement is more appropriate for children, such movements are very beneficial and in harmony with a young organism (Ibid.), and mastering the proper sprinting technique is important for prevention of injuries and uncontrolled falls caused by poor running performance and poor coordination of movements which is not compatible with the running speed. It is known that the most important abilities and features for engaging in athletic disciplines are best developed in certain, sensitive stages of life (Sozanski, 1981; Zeličenok, 1998), and it is assumed that the largest increase in running speed can be achieved if the training begins before puberty. In that period, the speed is naturally developed: from 7th to 11th and from 13th to 14th year in girls and from 7th to 10th and from 15th to 16th year in boys (Sozanski, 1981). Vraneković, Tkalčić & Horvatin-Fučkar (2008) studied the relations between anthropometric dimensions and 60 m running on a sample of 345 students aged 13 years ± 6 months. The results have shown that anthropometric variables in both manifest and latent space have significant impact on the outcome of sprinting. Given the necessity of timely orientation of children for athletic disciplines, it is important to be able to perform effective and applicable

verification of those abilities and characteristics that have contribution in achievement of better results in sprinting. Therefore, the objective of this study was to examine the connection between motor ability strength and achievement of results in sprinting in order to define strength tests to perform selection in physical education classes, at the age of early puberty.

METHODS

The study was of transversal character, conducted during two weeks at physical education classes, where, after adequate preparation through introductory and preparatory part of the class, the value of the variable speed was determined during the main part of the first class, and the variable strength was determined at the second class. The sample consisted of 88 girls (12 years ± 6 months) in the fifth grade, selected by random choice method. A systematic review has found that they were healthy and without injuries of the locomotor apparatus. Also, they were not involved in a training process, engaged in organized recreational activities and they were not prepared for the research by some exercise program.

The batery of four tests was used for evaluation of the motor ability strength, prescribed in the curriculum for the subject Physical Education of the Pedagogical Association of Vojvodina: variables of explosive strength - standing broad jump (cm), throwing medicine ball from lying position (m), variable of repetitive strength - sit-ups (number of successful attempts) and variable of isometric strength - bent arm hang (s). For evaluation of the motor ability speed, the standardized test was applied, which represented the criterion variable - the result obtained in 60 m run (s).

The SPSS 20.0 statistical program was used to calculate basic statistical parameters (arithmetic mean and standard deviation), whereas the linear regression analysis was applied to pre-formed sub-sample of girls, in order to determine connectivity and prediction of the system of predictor variables with the criterion variable.

RESULTS

Table 1 Descriptive statistics of analyzed variables

Variable	AM	SD	KS-test
Standing broad jump	177.20	24.310	0.13
Throwing medicine ball from lying position	5.73	4.18	0.73
Sit-ups	39.54	7.129	0.18
Bent arm hang	53.08	26.529	0.49
60 m run	12.30	3.993	0.32

Legend: AS-arithmetic mean; SD-standard deviation; KS-test Kolmogorov-Smirnov test

Table 1 shows central and dispersion parameters. Based on them, it can be concluded that the highest values of standard deviations are observed in the tests standing broad jump and bent arm hang, which indicates the fact that the results of these tests deviated the most from the average value of this sample of subjects. This can be attributed to a variety of daily physical activities of children in their spare time. When talking about the homogeneity of the results, it

can be concluded that the highest homogeneity of the results, around arithmetic mean, was obtained in 60 m run and throwing medicine ball from lying position.

Table 2 shows the results of regression analysis of motor abilities, that is, the analysis of the prediction of the system of predictor variables on the criterion variable, that is, on the result obtained in the 60 m run in girls.

Table 2 Regression analysis

Variable	r	p	r_{part}	p_{part}	Beta	p_{bete}
Standing broad jump	0.67	0.00	0.08	0.001	-0.576	0.001
Throwing medicine ball from lying position	0.62	0.00	0.02	0.523	0.156	0.523
Sit-ups	0.64	0.00	-0.11	0.000	-0.135	0.000
Bent arm hang	0.59	0.00	0.24	0.397	-0.123	0.397
R=0.633		**R^2=0.492**		**P=0.000**		

Legend: r - Pearson correlation coefficient; p - level of statistical significance for r; r_{part} - partial correlation coefficient; p_{prat} - level of statistical significance for r_{part};Beta - regression coefficient; pbete - level of significance of regression coefficient; R - multiple correlation coefficient; R2 - determination coefficient; P - significance of coefficient of multiple correlation

After examining this table, it was determined that the results of the examined criterion can be statistically significantly predicted based on the results of the system of predictor variables (p=0.00) at the value of multiple correlation coefficient R=0.633, which explains 49.2% of the common variability, while the other percentage may be attributed to some other factors which are not included in the given predictor system, and are directly connected with the efficiency of sprinting technique and achievement of the results (stride length, phases of resistance, duration of foot contact with the ground, other longitudinal dimensions, cognitive and connative characteristics, condition of the muscles, inter- and intramuscular coordination). Likewise, by observing the individual results of some of the variables, it can be concluded that the results of criterion variable can be statistically significantly predicted based on the results of variables standing broad jump (p=0.00) and sit-ups (p=0.00). Girls with higher values of the said predictor system of variables have achieved better results in the test for assessing the running speed, which means that more detailed and further training for manifestation of explosive leg strength and repetitive torso strength could contribute to improved results in the 60 m run in these subjects. Also, based on the Pearson correlation coefficient, it can be concluded that subjects with higher values of the variable for motor ability strength have achieved statistically more significant ($p \leq 0.01$), better results in the test for assessing the sprinting speed.

The results of partial correlation from the same table indicate that, for the most part, the result of the 60 m run is determined by the variables standing broad jump (p_{par}=0.001) and sit-ups (p_{part} p= 0.000). It can be noted that other analyzed variables for assessing other forms of strength - explosive arm strength (throwing medicine ball from lying position) and strength endurance (bent arm hang), diminish the possibility of achieving better results in this sample of subjects (after partialisation, the coefficient of partial correlation was significantly reduced compared to the Pearson coefficient).

DISCUSSION

The study showed a relatively equal prediction of criterion variable results on the basis of results of a set of predictor variables that have analyzed various forms of strength, which clearly indicates the importance of determining the factors associated with sprinting. Zagorac (1984) researched the association of motor abilities, but in 600 m run (among other tests), and he proved that motor abilities are strongly and positively associated with the running result, which means that development of motor skills can improve the running results in children 11-13 years old. Mihajlović & Tončev (2008) argue that decisive parts of technique for top performance in the future competition are being adopted at the age of 14 to 19 years, and therefore they believe that a very important fact is to start with the development of motor skills and improvment of their level two years before that, so the technique can later be perfected and the best results reached. The research project MZOS RH, conducted in 2003/2004, contained a study which referred to children of primary school age, and it examined motor abilities along with the attendance of athletics, sprint running, as additional physical activity. The results were that motor abilities were improved thanks to attendance of athletic in the form of sprinting. This means that, in addition to development of motor abilities in order to improve results in short distance running, the short distance running technique has to be exercised in order to improve the running result. Most of the researchers argue in their studies that the inborn coefficient is responsible for the level of speed as motor ability 95%, while possible improvement of the same by exercising can be only 5% (Wilmore & Costill, 1994). Due to complexity of anatomical and physiological structure of the movement apparatus and different structure of muscle fibers and dimensions of particular segments of human body, it is difficult to determine the ideal model of movement of short distance runners. This is why scientific literature and training practice deal mostly with the issues of general laws of muscle contraction and mutual influence of particular groups of muscles while executing maximum quick movements. Researches of Opavski (1975) indicate that short distance running speed is shown in the last support period, while the additional factors are the swing of the swinging leg and the swing of the opposite arm. Because of the greater mass and greater amplitude of movement, including a technical detail such as the swing of the swinging leg, which represents a significant part of the basic factor that in the last support (resistance) period, the side of swinging leg moves faster than the side of stepping leg. Runners should attempt to place the front part of the foot closer to the vertical projection of the center of gravity of the body (in accordance with the speed of movement), to shorten the amortization phase. At the end of the racing section there is a speed reduction. The cause of this phenomenon is a constant task of researchers, but most likely the cause is the change in the functional state of the central nervous system and local fatigue of actual muscle groups (Bompa, 2006).

Given that the aim of this study was to determine which of the tests for prediction of strength, as prescribed by the syllabus for subject Physical education, can be used to assess predispositions for short distance running in early age of girls, and with respect to all of the above, it can be concluded that this sample showed direct correlation of two forms of strength - explosive leg strength and repetitive torso strength with the result of 60 m run. Developing the maximum speed requires a very subtle intermuscular coordination of muscle groups of the lower extremities, of which the most important role is played by the following muscles: m. gluteus maximus, m. tibialis anterior, m. soleus, m. gastrocnemius, m. rectus femoris, m. biceps femoris, m. vastus lateralis (Čoh & Bošnjak, 2010), which is associated with the obtained results of this study, since the specified muscles provide explosive leg strength and, together with abdominal

muscles (which provide repetitive torso strength), are part of the chain of movement required for efficient short distance running. Therefore, it was determined that, for this sample of subjects, it was possible to make selection for short distance running on the basis of the results obtained in these strength tests, and that these two tests are usable in estimating the motor value of speed, and that it is necessary for them to continue to be implemented within the curriculum of Physical Education.

CONCLUSION

With reference to the results obtained in this study, it can be concluded that the running speed as the motor ability, which was analyzed by 60 m run test in girls aged 12 years, can be statistically significantly predicted on the basis of the results of some tests that assess various aspects of strength as a motor ability, as confirmed by research (Babić, 2005; Strel, Bizjak, Starc & Kovač, 2009; Vraneković, Tkalčić & Horvatin-Fučkar, 2008), who, on a similar sample of subjects, have proved that motor abilities are positively associated with the result in 60 m run. The obtained study results showed that not all the variables had demonstrated statistical significance. The variables that were distinguished as those that contribute most to the improvement of manifestation of speed as motor ability are standing broad jump and sit-ups, and that increasing their values leads to improvement in manifestation of speed measured by 60 m run test. The importance of research of this nature is reflected in the improvement of sports science, because it allows for understanding of sport talent, and therefore predicting the sport achievements. The existence and availability of such researches clarifies the issue of finding talents and eliminates subjectivity of sports experts in selection. Knowing the abilities and features that are critical for success in sports is important for the proper selection and orientation of potential athletes, and especially for programming and implementation of teaching and training process and for monitoring the results of these processes. Analysis of the obtained ability results can offer specific and optimal solutions and therefore the loss of time and wrong orientation can be avoided.

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SAŽETAK

Cilj istraživanja bio je da se ispita povezanost motoričke sposobnosti snage sa postizanjem rezultata u sprinterskom trčanju radi definisanja testova snage kojima se može vršiti selekcija na časovima fizičkog vaspitanja u uzrastu ranog puberteta. Uzorak je činilo 88 ispitanika ženskog pola uzrasta 12 godina (± 6 mjeseci). Za procenu motoričke sposobnosti snage korištena je baterija od četiri testa koji su propisani nastavnim planom i programom predmeta Fizičko vaspitanje Pedagoškog saveza Vojvodine: varijable eksplozivne snage - skok u dalj iz mesta (cm), bacanje medicinke iz ležanja na leđima (m), varijabla repetitivne snage - podizanje trupa (broj uspešnih pokušaja) i varijabla izometrijske snage - izdržaj u visu zgibom (s). Za procenu motoričke sposobnosti brzine primenjen je standardizovani test koji je predstavljao kriterijumsku varijablu - rezultat postignut u trčanju na 60 m (s). Povezanost sistema prediktorskih varijabli sa kriterijumskom varijablom izračunat je linearnom regresionom analizom, a rezultati istraživanja su pokazali da se na osnovu rezultata prediktorskog sistema varijabli statistički značajno može predvideti nivo sprinterske brzine trčanja. Pojedinačnim posmatranjem varijabli može se uočiti da varijable skok u dalj iz mesta (p=0,00) i podizanje trupa (p=0,00) ostvaruju statistički značajno predviđanje brzine trčanja na 60 m. Analizirajući rezultate regresione analize, može se pretpostaviti da se rezultat u trčanju na 60 m kod selektovanih ispitanica može predvideti na osnovu manifestacija eksplozivne snage nogu i repetitivne snage trupa.

***Ključne riječi**: sprinterska brzina, snaga, devojčice, eksplozivna snaga, repetitivna snaga.*

GENERALIZED SELF-EFFICACY OF HANDBALL PLAYERS ACCORDING TO PLAYING POSITION IN THE TEAM

GENERALNA SAMOEFIKASNOST KOD RUKOMETAŠA U ZAVISNOSTI OD POZICIJE U TIMU

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SUMMARY

The aim of this study is to determine statistic significant differences in self-efficacy of handball athletes according to their playing position. The sample consists of 127 handball players from 10 clubs in Serbia, 83 of them are males and 44 are females. All participants are divided in 4 groups (wing, back player, goalkeeper and line player), with an assumption that there are no significant differences between male and female handball players (p= .909). General Self-Efficacy Scale (SGSE; Schwarzer, & Jerusalem, 1981) is applied. Results indicate that there are no significant differences in self-efficacy beliefs in handball players according the playing position in the team (p= .581); handball players on each playing position in the team is equally assured in their skills, regardless the fact that the position activities will affect the outcome of the game. As regards the findings of previous studies and the specificity of handball, this paper provides possible explanation of the obtained results and their implementation in everyday activities of athletes and coaches.

Key words: *self-efficacy, playing position, handball players*

INTRODUCTION

Every position in sport implies a sequence of specific situations that requires player's assurance that his abilities will influence successful outcome of the match. Regarding handball, it is known that each position in offense must have specific technical, physical and psychological demands (Clanton & Dwight, 1997). Thus, one of the psychological demands is self-efficacy which represents a player's assurance of his skills. According to Bandura (Bandura, 1997), self-efficacy directly affects performance of an athlete. Bandura indicates that self-efficacy is situational specific which implies that each position in handball, based on its specificity, demands a certain level of self-efficacy. Thus, there is positive linear relationship with levels of general self-efficacy and performance (Haney & Long, 1995). However, self-efficacy in sport (Feltz, 2007) represents a problem which has been explored in recent decades, following the context of sport participation at different levels of competition and different types of sports activities.There are several studies regarding self-efficacy according to playing position in the team (Weigand & Stockham, 2000; Michele, 2006). In a study with field hockey players, Weigand and Stockham (Weigand & Stockham, 2000) determined statistically significant differences in self-efficacy according to playing position in the team where players on defense and midfield positions had higher scores then players on positions in offense. However, Michele (Michele, 2006) in his doctoral thesis explored the university rugby player selections under 19 years and found statistically significant differences in self-efficacy between rugby players at different positions in the team. In such a way, the findings of Michele suggest that rugby players on playing positions of locks and back three had significantly lower self-efficacy scores compared to other positions. We also noticed that previous findings of self-efficacy and the level of competitive state anxiety have shown that these two indicators of stress coping are related (Treasure, Monson & Lox, 1996). Thus, the level of competitive state anxiety according to playing position in the team will also be discussed. The level of competitive state anxiety according to playing position in the team was the subject of several studies (Sewel & Edmondson, 1996; Guillen & Sanchez, 2009) whose findings showed relative opposition. In a study conducted by Guillen and Sanchez (Gullien & Sanchez, 2009), no significant differences were found in the level of competitive state anxiety between basketball players according to their playing position in the team. However, according to the study of Sewel and Edmondson (Sewel & Edmonson, 1996) with university football players and field hockey players, significant differences were found in the level of competitive state anxiety, since where the players on the goalkeeper positions and defense positions had lower levels of competitive anxiety comparing to those on other positions.

Main goal of this study is to determine statistic significant differences in generalized self-efficacy of handball athletes according to their playing position.

METHODS

The total sample consists of 127 athletes (83 male handball players and 44 female handball players), from senior squads. Research included 10 clubs in Serbia (6 male clubs, 4 female clubs). All participants are divided in four groups which were formed according to their playing position: *goalkeepers* (n=19), *backs* (n=48), *wings* (n=43), *line players* (n=17), according the gender: *males* (n=83) and *females* (n=44), and according their level of

competition: *Super League* (n=18), *Super B* (n=39), *First League* (n=53) and *Second League* (n=17).

A Generalized Self-Efficacy Scale questionnaire (SGSE) was applied (Schwarzer & Jerusalem, 1981; cited in Weinman, 1995). Questioner is Likert questionnaire, with 4 statements representing the degree of agreement or disagreement. The questionnaire consists of 10 items which are related to optimistic self-beliefs in coping with stressful situations. Reliability of the questionnaire according to Cronbach alpha is between 0.76 and 0.90 according to several studies (Cable & Judge, 1994; Earley & Lituchy, 1991; Gardner & Pierce, 1998; Riggs & Knight, 1994; Schaubroeck & Merritt, 1997; Smith & Foti, 1998; cited by Chen, Guly & Eden, 2001). Research was conducted in 10 handball clubs in Serbia. Clubs included in research are: *RK "Jugović" Kać, RK Žabalj, RK Jabuka, ŽRK "Dinamo" Pančevo, ŽRK „Radnički" Obrenovac, RK „Radnički" Obrenovac, ŽRK „Radnički" Kačarevo, ŽRK „Proleter" Zrenjanin, Rk „Proleter" Zrenjanin i RK Voždovac Beograd.* The study includes a sample of independent variables: the position in the team (goalkeeper, external attacker, wing, pivot), while the predictor variable represented: self-efficacy (generalized self-efficacy).

We used IBM SPSS statistics software for statistical analysis, which implied Shapiro-Wilk normality test, also Mann-Whitney and Kruskall-Wallis test of differences between groups and to analyze them.

RESULTS

Regarding the fact there are no significant differences in self-efficacy between gender (p=.654) showed in Table 3, nor between participants of different level of competition (p=.500) presented in Table 4, the presentation of results is based on the sample of a homogenous group, so that differences in self-efficacy were analyzed through playing position only.

Table 1 Shapiro-Wilk normality test by groups according to playing position

	goalkeeper	back	wing	line player
	N=19	N=48	N=43	N=17
	p	p	p	p
Self-efficacy	.184	.004	.185	.164

Legend: Statistical significance of Shapiro Wilk test of normality set on $p \leq 0.05$

Results in Table 1 indicate that there are significant deviations from normal distribution in group *backs,* while there are no significant deviations in other groups. Table 2 shows descriptive characteristics in self-efficacy according to the playing position.

Table 2 Descriptive characteristics according to playing position

	goalkeeper		back		wing		line player	
	N=19		N=49		N=43		N=17	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Self-efficacy	3.43	0,35	3.31	0.35	3.25	0,42	3.31	0.28

The results shown in Table 2, according to the arithmetic mean values in self-efficacy, indicate the similarities between the groups.

Tables 3 and 4, presents the results of differences analysis between groups according to gender and level of competition.

Table 3 Mann Whitney test between groups according to gender

	Males	Females	Mann-Whitney
	N=83	N=44	N=127
	Mean Ranks	Mean Ranks	p
Self-efficacy	62.94	66.00	0.654

Legend: Statistical significance of Mann Whitney test set on level $p \leq 0.05$

Table 4 Kruskal-Wallis test between groups according to level of competition

	Super League	Super B	First League	Second League	Kruskal Wallis
	N=18	N=39	N=53	N=17	N=127
	Mean Ranks	Mean Ranks	Mean Ranks	Mean Ranks	p
Self-efficacy	73,97	64,04	63,47	55,00	0,500

Legend: Statistical significance of Kruskal-Wallis test set on level $p \leq 0.05$

Results from Table 3 and 4 indicate there are no significant differences in self-efficacy beliefs between handball players, according to gender and level of competition. However, significance of these results will be included in further analysis, in order to isolate variable *playing position*.

Table 5 shows Kruskal-Wallis test results between groups in self-efficacy according to playing position. The figures in first column show Mean Ranks for each group.

Table 5 Kruskal-Wallis test between groups according to playing position

	goalkeeper	back	wing	line player	Kruskal Wallis
	N=19	N=49	N=43	N=17	N=127
	Mean Ranks	Mean Ranks	Mean Ranks	Mean Ranks	p
Self-efficacy	73,94	64,57	59,83	62,06	0,581

Legend: Statistical significance of Kruskal-Wallis test set on level $p \leq 0.05$

Results in Table 5 indicate that there are no significant differences in self-efficacy according to playing position in the team.

Table 6 shows median position in self-efficacy for each playing position in the team.

Table 6 Median values for each group in self-efficacy according to playing position

playing position	goalkeeper	back	wing	line player
	N=19	N=49	N=43	N=17
	Median	Median	Median	Median
Self-efficacy	3.40	3.30	3.30	3.40

Results from Table 6 show that median position is relatively identical for each playing position in the team.

DISCUSSION

Results of this study indicate that there are no significant differences in self-efficacy beliefs according to playing position of handball players (p=.581). However, results in our study are not consistent with previous studies which explored differences in self-efficacy according to playing position in the team (Weigand & Stockham, 2000; Michele, 2002). Moreover, we must indicate differences in dividing the groups. Weigand divided the groups by positions of *midfield, defense* and *offense,* as our study followed Bray, Balaguer and Duda (Bray, Balaguer & Duda, 2004) divide method, under the standpoint that higher self-efficacy improves a player's performance according to their playing position in the team predominantly in offensive tasks. Hence, our study used group split according to playing positions strictly in offense, except goalkeeper. In a study conducted by Michele (Michele, 2006), positions of locks and back three have significantly lower self-efficacy compared to other positions, but the author indicates that these positions have bigger impact on the outcome of the match. In our study, each position has equal impact on the outcome of the match.

Studies about the level of competitive state anxiety which found significant differences in the level of competitive state anxiety according to playing position in the team (Sewel & Edmonson, 1996, Guillen & Sanchez, 2009) are partially supported by the results from our study. According to Sewel research (Sewel & Edmonson, 1996) who found significant differences in the level of competitive state anxiety according to which goalkeepers had lower scores of competitive anxiety comparing to other positions. However, similarly with Weigand study (Weigand & Stockham, 2000), the total sample was divide in groups: *goalkeeper, defense, midfield, offense*. Regardless the difference in sample divide method, the results from our study indicate that there are no significant differences between goalkeepers and rest of the positions in self-efficacy. In a study conducted by Guillen and Sanchez (Guillen i Sanchez, 2009) results indicate that there are no significant differences (p=.07) in the level of competitive state anxiety according to playing position of basketball players. Though, their findings are in direct match with ours, we should indicate the differences in the sizes of total sample. Hence, the result would be different if their sample number would match similar number of our study.

CONCLUSION

We must point out that the limit of this study is the fact that some of the factors like personality traits or emotional status or interpersonal relations in the squad were not controlled to help explore the effect of playing position in the team on self-efficacy beliefs. However, these results indicate that according to each position in a handball team, is equally assured of their skills, regardless the fact that some positions can affect the outcome of the game. These results drew attention to the field of research in sport science dealing with psychological aspects of training in competitive sport. Thus, handball practitioners and players should strive to build up their situational specific self-efficacy beliefs regarding each position.

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SAŽETAK

Cilj istraživanja je da se utvrdi da li postoje statistički značajne razlike u generalnoj samoefikasnosti kod sportista koji se bave rukometom u zavisnosti od njihove pozicije u timu. Uzorak ispitanika obuhvata 127 ispitanika, od toga 83 rukometaša i 44 rukometašice, iz 10 rukometnih klubova u Srbiji. Uzimajući u obzir da ne postoje statistički značajne razlike u generalnoj samoefikasnosti između ispitanika različitog pola (p= 0,909), ukupan uzorak je na osnovu varijable pozicija u timu podeljen u četiri grupe: golman (n=19), spoljni napadač (n=48), krilo (n=43), kružni napadač (n=17). U istraživanju je primenjena Skala generalne samo-efikasnosti (SGSE; Schwarzer & Jerusalem, 1981). Rezultati pokazuju da ne postoje statistički značajne razlike u generalnoj samoefikasnosti kod sportista u zavisnosti od njihove pozicije u timu (p= 0,581); svaka pozicija u timu je relativno jednako uverena u svoje sposobnosti, bez obzira da li će od nje da zavisi ishod utakmice. Polazeći od rezultata prethodnih istraživanja i specifičnosti rukometa, u radu se diskutuju moguća objašnjenja rezultata, odnosno njihovo značenje kod sportista i trenera u treningu i takmičenju.

Ključne reči: samoefikasnost, rukometaši, rukometašice, pozicija u timu.

EFFICIENCY OF KINESIO TAPING IN PREVENTION AND REHABILITATION OF SPORT INJURIES

EFIKASNOST KINEZI TRAKA U PREVENCIJI I REHABILITACIJI SPORTSKIH POVREDA

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SUMMARY

Kinesio Tape is becoming more widely used in sports physiotherapy and for postural rehabilitation. Many professional athletes use the tape to support injured, fatigued, or overused muscles. The tape's construction is unique, featuring a highly elastic property that engages both the muscles and fascia. It is claimed that KT supports injured muscles and joints and helps relieve pain by lifting the skin and allowing improved blood and lymph flow. The aim of this review was to evaluate, using meta-analysis, the effectiveness of KT in the treatment and prevention of sports injuries. Electronic databases including SPORTDiscus, Scopus,MEDLINE, ScienceDirect and sports medicine websites were searched using keywords 'kinesio taping/tape'. The efficacy of KT in pain relief was trivial given there were no clinically important results. There were inconsistent ranges of motion outcome results, with at least small beneficial results seen in two studies, but trivial results in two other studies across numerous joint measurements. There was a likely beneficial effect for proprioception regarding grip force sense error, but no positive outcome for ankle proprioception. KT had some substantial effects on muscle activity, but it was unclear whether these changes were beneficial or harmful. In conclusion, there was little quality evidence to support the use of KT over other types of elastic taping in the management or prevention of sports injuries. KT may have a small beneficial role in improving strength, range of motion in certain injured subjects and force sense error compared with other tapes, but further studies are needed to confirm these findings.

Key words: sport medicine, kinesitherapy, recovery, atrophy

INTRODUCTION

Taping is widely used to prevent injury to athletes (Thelen, Dauber & Stonerman, 2008). Kinesio tape, invented by Kenzo Kase in 1996, is a new application of adhesive taping (Liu, Chen, Lin, Huang & Sun, 2007). It is claimed that KT supports injured muscles and joints and helps relieve pain by lifting the skin and allowing improved blood and lymph flow (Kahanov, 2007). Tape is used to treat anything from headaches to foot problems and everything in-between. Examples include rehabilitation from sports injuries, carpal tunnel syndrome, lower back strain/pain (subluxation, herniated disc), knee and shoulder conditions, and many more (Lim, Park & Bae, 2013).

According to the KT training manual (Kase & Wallis, 2002), KT is highly stretchable (up to 75% of its original length) and its working mechanism is based on the taping direction and tension. Kase described KT applications for both "muscle facilitation" and "muscle inhibition" technique. KT applying from the muscle origin to insertion with stronger tension i.e. 50-75% of its original length may enhance muscle contraction (Kase, K., Wallis & Kase, T. 2003). On the contrary, muscle contraction may be reduced by applying KT from the muscle insertion to origin with weaker tension i.e. 15%-25% of its original length (Kase, K., Wallis & Kase, T. 2003).

There are many proposed benefits of KT including proprioceptive facilitation (Halseth, T., McChesney, J.W., DeBeliso, M., Vaughn, R. i Lien, J. 2004; Jaraczewska & Long, 2006; Riemann & Lephart, 2002), muscle facilitation (Hammer, 2006), reduced muscle fatigue, reduced delayed-onset muscle soreness (Nosaka, 1999), pain inhibition (Kahanov, 2007; Kneeshaw, 2002), enhanced healing such as reducing oedema, improvement of lymphatic drainage and blood flow (Kase, Hashimoto & Tomoki, 1998; Kinesio Holding Corporation, 2008; Lipinska, Sliwinski, Kiebzak, Senderek & Kirenko, 2007; Zajt-Kwiatkowska, Rajkowska-Labon, Skrobot, Bakula & Szamotulska, 2007).

Furthermore, Dr. Kenzo Kase claimed that one of the effects of KT is to increase muscle strength (Kase, K., Wallis & Kase, T. 2003). KT can facilitate muscle activity through concentric pull of the fascia, if applied from muscle origin to it's insertion (Hammer, 2006). KT can be applied literally on every human joint or muscle. However, there is no enough evidence which would advocate the use of KT in the treatment and rehabilitation after injuries. Limited number of studies, concerning the use of KT, show that KT might be use in order to enhance functions of human locomotion. In addition, KT can help in reducing pain, then, increasing stability and proprioception in patients with acute dislocation of patella, stroke, pain in joints and in states of trunk dysfunction.

These information come from series of studies and pilot studies thereby representing lower levels of clinical evidence. It seems that KT might be useful toll in rehabilitation and treatment of injured anthletes, but there is no enought studies to confirt that statement.

METHODS

Cochrane Collaboration review methodology (literature search, assessment of study quality, data collection of study characteristics, analysis and interpretation of results, recommendations for clinical practice and further research) was used to evaluate the effectiveness of KT in the treatment and prevention of sports injuries. Electronic data bases including SPORTDiscus,Scopus, MEDLINE, ScienceDirect, and sports medicine websites were searched using keywords 'kinesio taping/tape'. Of the 96 articles sourced ten studies

were used for meta-analysis using the following inclusion/exclusion criteria: (i) the article reported data for effect of KT on a musculoskeletal outcome (e.g. pain, range-of-motion, proprioception); (ii) the article had a KT group and a comparison group (e.g. KT applied without tension, placebo taping, no taping); and (iii) the full version was available in English. The quality of the ten papers that met our inclusion/exclusion criteria was assessed based on the following key components of the methodological quality: (i) randomization of subject allocation; (ii) blinding of subjects; and (iii) blinding of all assessors. These criteria have been identified as being fundamental in reducing bias in clinical trials. For the ten studies included, data were extracted including participants' characteristics, study design, methodological quality, interventions, outcome measures and results (see table I).

A number of outcome measures were used to evaluate the effectiveness of KT, including strength, pain, range of movement, proprioception and muscle activity. We analyzed all statistically significant results reported within the ten studies, and made clinical inferences regarding the true value of their effects in a manner outlined by Batterham and Hopkins. Results that were not reported as being statistically significant were also assessed (where sufficient data were provided), and any results found to be of benefit in our analysis are discussed within the following sections.

RESULTS

An overview of details of the ten studies metaanalysed are summarized in table I. Tables II and III summarize the reported positive statistical results of KT, and our interpretation of the magnitudes of the effects and their clinical importance. Eight studies reported a statistically significant positive outcome for at least one outcome measure.

Table I. *Characteristics of studies which studied the effectiveness of kinesio taping (KT) on strength, pain, range of motion (ROM), proprioception or muscle activity*

Study	Study quality	Study aim	Study design	Subject characteristics
Thelen, Dauber i Stonerman, 2008	4	Effect of KT vs sham treatment on pain and ROM	Randomized, blinded clinical trial	Control group: 20-2y, 17 M, 4 F. Experimental group: 21 –2y; 19 M, 2 F. All patients clinically diagnosed with rotator cuff tendonitis/impingemnt
GonzaLez-Iglesias et al., 2009	4	Effect of KT vs sham treatment on neck pain and cervical ROM in individuals with acute whiplash-associated disorders	Randomized, blinded clinical trial	Control group: 32-7y; 10 M, 10 F. Experimental group: 33 –6y; 10 M, 11 F. All patients reported neck pain as a result of a motor accident
Hsu et al., 2009	3	Effect of KT vs placebo taping on kinematics, muscle activity and strength of the scapular region in baseball players with shoulder impingement	Randomized crossover, pre- and post-test repeated measures design. Examiners were blinded	17 amateur baseball players with shoulder impingement: 23-3y
Chang et al., 2010	3	Effect of KT vs placebo and notaping on maximal grip strength and force sense of healthy collegiate athletes	Randomized, blinded repeated measures design with single group	21 healthy collegiate athletes: 21-3y
Vithoulka et al., 2010	2	Effect of KT vs placebo and notaping on quadriceps strength	Randomized repeated measures design	20 healthy nonathlete F: 27-4y

		at maximum concentric and eccentric isokinetic exercise		
Yoshida i Kahanov, 2007	2	Effect of KT vs no-taping on trunk flexion, extension and lateral flexion	Randomized crossover, pre- and post-test repeated measures design	30 healthy subjects: 27-6y; 15 M, 15 F
Fu et al., 2008	2	Effect of KT vs no-taping on muscle strength in quadriceps and hamstring	Muscle strength assessed in three conditions (without KT, immediately after application of KT and 12 h after taping with tape still in situ). Randomized order of three conditions	14 healthy college athletes: 20-1y; 7 M, 7 F
Halseth et al., 2004	2	Effect of KT vs no-taping on ankle proprioception (reproduction of joint position sense)	Randomized repeated measures design	30 healthy subjects: 18-30 y; 15 M, 15 F
Lee, Yoo and Lee, 2010	2	Effect of KT vs no-taping on grip strength	Randomized repeated measures design	40 healthy subjects: 23-2y; 20 M, 20 F
Slupik et al., 2007	1	Effect of KT vs no-taping on bioelectrical activity of vastus medialis muscle	Non-randomized control trial	27 healthy subjects: 23 -4y; 15 M, 12 F

a Study quality was ranked 1–4 where the larger number indicates better quality: 4 = controlled experimental study, with randomization of subject allocation, plus blinding of subjects and assessors; 3 = controlled experimental study, with randomization of subject allocation, and blinding of subjects but not assessors; 2 = controlled experimental study, with randomization of subject allocation, but no blinding of subjects or assessors; and 1 = controlled experimental study that lacked randomization of subject allocation and blinding of subjects and assessors.
b Age data in years are presented as mean – standard deviation or ranges where stated
F = female; **M**= male

Table II. *The effects of kinesio tape on range of motion*

Study	Outcome measure	Treatment comparison	Reported positive outcome	Smallest beneficial difference
Thelen, Dauber i Stonerman, 2008	ROM	KT vs placebo treatment	19.1±10.8° (pain-free shoulder abduction; day 1)	15° increase
GonzaLez-Iglesias et al., 2009	ROM	KT vs placebo treatment	6.6±1.1° (cervical flexion immediate post)	9.6° increase
			7.4±1.8° (cerv. flexion 24h)	9.6° increase
			8.2.±1.7° (cerv. Extension immediate post)	7.0° increase
			8.5±2.0° (cerv. extension 24h)	7.0° increase
			5.4±1.3° (cerv.right lateral flex.immediate post)	5.9° increase
			5.8±1.5° (cerv.right lateral flex. 24h)	5.9° increase
			3.1±1.9° (cerv.left lateral flex.immediate post)	9.1° increase

			2.3±1.9° (cerv.left lateral flex. 24h 24h)	9.1° increase
			5.5±1.5° (cerv.right rotation immediate)	7.6° increase
			6.1±1.8° (cerv.right rotation 24h)	7.6° increase
			5.2±1.4° (cerv.left rotation immediate)	6.7° increase
			4.1±1.5° (cerv.left rotation 24h)	6.7° increase
Hsu et al., 2009	ROM	KT vs placebo treatment	1.1±0.7° (posterior tilt at 30° humeral elevation)	1.2° increase
			1.2±0.8° (posterior tilt at 60° humeral elevation)	1.2° increase
Yoshida i Kahanov, 2007	ROM	KT vs no taping	17.8±14.8 cm (trunk flexion)	6.37 cm (10% increase no taping)

KT = kinesio tape; **ROM** = range of motion; **Cerv**. = cervical

Table III. *The effects of kinesio tape on pain, proprioception, strength and muscle activity*

Study	Outcome measure	Treatment comparison	Reported positive outcomes	Smallest beneficial difference
GonzaLez-Iglesias et al., 2009	Pain	KT vs placebo treatment	0.9±0.2 (NPRS immediate post-treatment)	2-point reduction
			1.1±0.3 (NPRS 24 h post-treatment)	2-point reduction
Chang et al., 2010	Proprioception	KT vs placebo treatment	2.5±2.1 kg	0.44 kg
			3.3±2.7 kg	0.84 kg
Hsu et al., 2009	Strength	KT vs placebo treatment	1.2±1.0 kg (handgrip strength change)	0.70 kg
Lee et al., 2010	Strength	KT vs no taping	2.9±2.4 kg (handgrip strength change in males)	1.6 kg
			1.6±1.3 (handgrip strength change in females)	1.04 kg
Vithoulka et al., 2010	Strength	KT vs placebo treatment	1.96±4.9 Nm (quadriceps peak torque at 60˚/s during eccentric exercise)	7.52 Nm
			9.88±7.3 Nm (quadriceps peak torque at 60˚/s during eccentric isokinetic exercise)	8.33 Nm
Fu et al., 2008	Strength	KT vs no-taping	3.2±1.7 kg/m (peak torque during concentric contraction of the quadriceps at 180°/s)	2.12 kg/m
Hsu et al., 2009	Muscle activity	KT vs placebo treatment	14.2±11.7 (increase in lower trapezius muscle activity at 60-30° humeral elevation)	10% change
			23.0±19.8% (decrease in	10% change

			upper trapezius muscle activity at 90-120° humeral elevation)	
Slupik et al., 2007	Muscle activity	KT vs no-taping	54±1.2% (increase in *vastus medialis* activity at 24h)	10% change
			22±1.1%(increase in *vastus medialis* activity at 72h)	10% change

KT = kinezi traka; NPRS = numerička skala za rejtiranje bola

DISCUSSION

Kinesio taping is a technique which uses the application of an elastic adhesive tape on the skin. KT is manufactured with elastic cotton which can be stretched from 120 to 140% its original length. It is used to pressurize the skin to affect the somato--sensory system under the areas where the tapes are applied (Kase & Wallis, 2002). Compared with conventional tape, it is suggested that KT allows a greater range of motion and can be worn for longer periods of time without the need for reapplication (Kase & Wallis, 2002). The proposed benefits of KT include facilitating joint and muscle realignment by strengthening weakened muscles (Kase & Wallis, 2002), improving circulation of blood and lymph by increasing the interstitial space between the skin and underlying connective tissues (allowing for increased circulation of both venous and lymphatic fluid), (Kase & Wallis, 2002) decreasing pain through the reduction in pressure on nociceptors, repositioning subluxed joints by relieving abnormal muscle tension, helping to return the function of fascia and muscle (Kase & Wallis, 2002), and increasing proprioception through the stimulation of cutaneous mechanorectors. KT can be applied literally on every human joint or muscle. However, there is no enough evidence which would advocate the use of KT in the treatment and rehabilitation after injuries. Limited number of studies, concerning the use of KT, show that KT might be use in order to enhance functions of human locomotion. In addition, KT can help in reducing pain, then, increasing stability and proprioception in patients with acute dislocation of patella, stroke, pain in joints and in states of trunk dysfunction.

It is claimed that KT reduce pain by stimulation of sensitive neural pathways, i.e. by increasing afferented feedback information. The proposed mechanism in which KT reduce pain is by reducing afferent impulses which come from nocioceptors. In addition, KT lifts the skin thereby decreasing the pressure on mechanoreceptors of skin. Form 10 assessed studies, only the study of (GonzáLez-Iglesias, Fernández-de-las-Peñas, Cleland, Huijbregts & Gutiérrez-Vega, 2009) reported statistically significant results for a measurement of pain. They noticed significant reduction of pain on a numerical pain rating scale (NPRS) in the KT group versus the sham treatment group for patients with acute whiplash-associated disorders.

One of proposed mechanism by which KT can increase range of motion is by increase of blood flow into the skin area which is covered with tape; physiological change which facilitate initiation of muscle movement. Additional theory is that fear is associated with intensity of pain in patients and so the application of KT provides sensory feedback that reduces fear of movement and thus increases range of motion (GonzáLez-Iglesias, Fernández-de-las-Peñas, Cleland, Huijbregts & Gutiérrez-Vega, 2009). Thelen, Dauber & Stoneman (2008) assessed the range of pain-free shoulder abduction in patients diagnosed with rotator cuff impingement, defining a clinically meaningful change as a 15˚ increase. Our clinical conclusion from these statements is that KT may have at least a small, useful short-term effect on the range of motion for certain joints in injured patients. Study of (GonzáLez-Iglesias, Fernández-de-las-Peñas, Cleland, Huijbregts & Gutiérrez-Vega, 2009) assessed cervical motion in six directions both immediately post treatment and 24-hours post-treatment. They

concluded that KT had a trivial effect on cervical range of motion for the vast majority of cervical motions, both acutely and 24-hours post-treatment.

Hsu, Chen, Lin, Wang & Shih (2009) investigated the effect of KT on shoulder kinematics in baseball players with shoulder impingement syndrome. The KT group had statistically significant improvements in scapular orientations compared with the placebo group for posterior tilt at 30˚ and 60˚ of humeral elevation, but no other measures of scapular orientationsor displacements were statistically significant. Measurements at 30˚, 60˚ and 90˚ of posterior tilt of the scapular were also possibly beneficial in our analysis, despite being reported as statistically no significant by the authors. Our analysis found trivial or unclear differences for the 19 other measurements of scapular orientations. No beneficial effects were inferred for any of the 24 scapular displacement measurements, with possibly harmful effects found for eight measurements. KT may have beneficial effects on improving scapular kinematics in subjects with shoulder impingement syndrome, but only for specific degrees of humeral elevation. Overall, the effect of KT is likely to be trivial, or even possibly harmful for certain measurements, and therefore would not be recommended for use in treatment of shoulder impingement syndrome. Yoshida & Kahanov (2007) assessed the effects of KT on trunk flexion, extension and lateral flexion in 30 healthy patients, using a randomized crossover design. There were positive changes for trunk flexion with a mean increase of 17.8 cm in the KT condition. However, the taping effect was not addressed given the comparison was a no-taping condition. The changes in lower trunk extension and lateral flexion were both nonsignificant, but the authors did not report specific p-values or confidence limits for us to make inferences about the magnitude of these results. The effect of KT on range of motion remains unclear because of the limited number of studies on a variety of joints, and the conflicting results. The beneficial effects of KT in the higher quality study conducted by (Thelen, Dauber & Stoneman, 2008), suggested KT may have at least a small, useful short-term effect on the range of motion for certain joints in injured cohorts. Beneficial effects were reported for cervical extension and right lateral flexion in patients with acute whiplash-associated disorders (GonzáLez-Iglesias, Fernández-de-las-Peñas, Cleland, Huijbregts & Gutiérrez-Vega, 2009) and for certain aspects of scapular kinematics (Hsu, Chen, Lin, Wang i Shih, 2009). Regarding all these statements, we would not recommend the use of KT for the enhancement of range of motion in injured patients. In healthy patients there was at least a small beneficial effect for trunk flexion, as recorded in the study of (Yoshida & Kahanov, 2007). However, given that placebo tapes were not used, we are not sure whether KT are useful or not comparing to traditional taping method.

It is proposed that KT may enhance muscle strength by initiating the concentric contraction of fascia which in turn stimulate, i.e. increase muscle contraction. KT might pull the skin or myofascia underneath the skin which helps release the tightened area of muscles and improve the flexibility (Lee J-H., Yoo & Lee K-S., 2010). In addition, KT may facilitate muscle activity and improve muscle alignment which can contribute to marginal increases in muscle strength (Hsu, Chen, Lin, Wang & Shih, 2009). Four of the ten studies reported positive outcomes in measures assessing strength. Study of (Lee J-H., Yoo & Lee K-S., 2010) evaluate effect of KT on handgrip strength in 40 healthy subjects. Handgrip strength was significantly higher for both males and females when KT was applied to the flexor muscles of the dominant hand compared with the no-taping condition. Both results were calculated to be likely beneficial in our analysis, however, as there was no placebo taping condition, these results should be treated with caution.

Vithoulka, Beneka, Malliou, Aggelousis, Karatsolis & Diamantopoulos (2010) investigated the effects of KT on quadriceps peak torque and reported a statistically significant increase for the KT condition during eccentric assessment. However, the significant differences were with regard to a one-way ANOVA result comparing KT, placebo

tape and no-taping conditions. However, study of Briem, Eythörsdöttir, Magnúsdóttir, Pálmarsson, Rúnarsdöttir & Sveinsson (2011), which assessed the effect of KT on the level of activation of the fibularis longus muscle during a "sudden disturbance" of the ankle in 51 healthy athletes, did not find significant alterations in muscle strength. On the other hand Hsu, Chen, Lin, Wang & Shih (2009), reported that KT application provoked a significant increase in the electromyography activity of the lower trapezius muscle during shoulder abduction in 17 athletes, underscoring that they exhibited shoulder impingement syndrome. Similar findings were reported by Firth, Dingley, Davies, Lewis & Alexander (2010), who found no alteration in single-hop distance, in either healthy subjects or those with Achilles tendinopathy, after KT application to the ankle. Hwang-Bo & Lee (2011) analyzed vertical hop height 30 min after KT application to the ankle, in healthy subjects, also finding no significant alteration. With respect to static balance Aytar, Ozunlu, Surenkok, Baltaci, Oztop & Karatas (2011) detected an improvement during KT application to the femoral quadriceps in women with patellofemoral pain syndrome. Few studies have assessed lower limb function and one-footed static balance after KT application, hindering analysis of the real effects of this technique on these variables.In addition, study of Alano, Neto, Amorim, Macedo & Brasileiro (2013) showed that KT application to *m. rectus femoris*, *m. vastus lateralis* and *m. vastus medialis* is not capable of altering lower limb function, one-footed static balance, peak knee extensor torque or activation amplitude of the VL muscle, in healthy women. Moreover, the application of nonelastic adhesive tape over the same area of skin did not significantly change these variables. Study of Fu, Wong, Pei, Wu, Chou & Lin (2008) examined the effect of KT on muscle strength in healthy collegiate athletes. One statistically significant result was reported for the concentric contraction of the quadriceps at 180˚/sec at 12 hours after taping, with tape still *in situ*.In contrast, Chang, Chou, Lin, J., Lin, C. & Wang (2010) reported no statistically significant difference in maximal grip strength measured under three conditions (without taping, with placebo taping and with KT) in 21 healthy collegiate athletes. There was also one unclear and eight trivial results for measurements of strength, which preclude a clear conclusion being made. Further studies on similar muscles, and in
particular KTs long-term effect on strength gain, warrant investigation.

There have been studies documenting a significant effect of the application of white athletic tape to the ankle on ankle proprioception (Karlsson & Andreasson, 1992; Robbins, Waked & Rappel, 1995; Heit, Lephart & Rozzi, 1996; Simoneau, Degner, Kramper & Kittleson, 1997). However, very little research has been done examining the effect alternative tape applications (such as that of Kinesio™ tape) may have on increasing cutaneous afference. Murray & Husk (2001) examined the effect of kinesio taping on ankle proprioception. They concluded that kinesio taping for a lateral ankle sprain improved proprioceptive abilities in non-weight bearing positions in the midrange of ankle motion where ligament mechanoreceptors were inactive. Study of Chang, Chou, Lin, J., Lin, C. & Wang (2010) examined the force sense error in grip strength measurements amongst 21 healthy collegiate athletes. They reported two positive results with respect to proprioception. Halseth, McChesney, DeBeliso, Vaughn, & Lien (2004) also examined the effects of KT on ankle proprioception. The KT group showed no statistically significant change in absolute error for ankle reproduction of joint position sense measurements for both plantar flexion and inversion, when compared to the untapped condition. There were not enough data available for us to make clinical inferences regarding these results.

In order to fully understand the effect of Kinesio tape on proprioception, further research needs to be conducted on other joints, on the method of application of Kinesio™ tape, and the health of the subject to whom it is applied. Further research may provide vital information about a possible benefit of Kinesio™ taping during the acute and sub acute phases of rehabilitation, thus facilitating earlier return to activity participation. It is unclear

what direction of change in muscle activity represents a beneficial effect; a decrease may imply KT is having a supporting effect and the muscle is working more efficiently, while an increase could represent a facilitatory effect and enhanced muscle function (Hsu, Chen, Lin, Wang & Shih, 2009). This is likely to be dependent on the specific muscle being assessed, the selected subjects (healthy or injured subjects) and the taping technique.Study of Lin, Hung & Yang (2011) showed significant changes in EMG activity in the scapular muscles with the application of tape in the asymptomatic group. Proprioceptive feedback was also enhanced with taping. Thus, the mechanisms by which scapular taping can be explained are neuromuscular control as well as proprioceptive feedback factors. Morin, Tiberio & Austin (1997) also found a significant decrease in muscle activity in the upper and middle trapezius region muscle with taping. Slupik, Dwornik, Bialoszewski & Zych (2007) reported a 54%increase in muscle activity of the vastus medialis muscle 24 hours after application of KT. This effect was inferred to be most likely substantial. After 72 hours there was a 22% mean increase, compared with baseline values resulting in an effect we calculated to be very likely substantial.

Changes in muscle activity 10 minutes and 96 hours after KT application were both trivial. However, the order in which subjects were measured under the two conditions (with and without KT) was not performed in a crossover manner, and therefore the order effects were not controlled for. There was no placebo group, and so we were unable to ascertain whether changes were specifically due to KT, or simply the effect of taping alone. As a consequence, the results of this study must be questioned. In the study of GonzáLez-Iglesias, Fernández-de-las-Peñas, Cleland, Huijbregts & Gutiérrez-Vega (2009) which investigate the impact of KT on muscle activity, KT was associated with a substantial change in muscle activity over specific ranges of humeral elevation. However, the majority of differences were trivial or unclear. Further research is required to determine whether the changes induced by KT were beneficial in the treatment of the injury.

CONCLUSION

The main purpose of our systematic review was to investigate effectiveness of KT in the treatment and rehabilitation of musculoskeletal injuries. The theory behind the use of KT is that the application of the tape improves lymphatic and blood circulation without restricting ROM and thus decreases pain, inflammation, and recovery times. Kinesio taping is attractive to active patients and high-level athletes looking for a therapeutic edge to improve outcomes, including performance, pain, function, and strength, following musculoskeletal injury.

We have searched electronic data bases including SPORTDiscus,Scopus, MEDLINE, ScienceDirect, and sports medicine websites, by typing keywords ‘kinesio taping/tape’. Of the 96 articles sourced ten studies were used for meta-analysis. Two studies investigated sport-related injuries (GonzáLez-Iglesias, Fernández-de-las-Peñas, Cleland, Huijbregts & Gutiérrez-Vega, 2009; Hwang-Bo & Lee, 2011), and only one investigated injuries in athletes (Hsu, Chen, Lin, Wang & Shih, 2009).

Studies have shown that KT might be used in the prevention and treatment of musculoskeletal injuries (GonzáLez-Iglesias, Fernández-de-las-Peñas, Cleland, Huijbregts & Gutiérrez-Vega, 2009; Hsu, Chen, Lin, Wang & Shih, 2009; Hwang-Bo & Lee, 2011; Kaya, Zinnuroglu & Tugcu, 2010; Lee, 2015; Mostafavifar, Wertz & Borchers, 2012; Thelen, Dauber & Stoneman, 2008). KT may have a small beneficial effect on strength, force sense error and active range of motion of an injured area, but further clarification is needed (Williams, Whatman, Hume & Sheerin, 2012).There was no substantial evidence to support

the use of KT for improvements in other musculoskeletal outcomes - pain, ankle proprioception or muscle activity (Williams, Whatman, Hume & Sheerin, 2012).

Our systematic review found insufficient evidence for or against the use of KT to improve pain, function, performance following musculoskeletal injury. The number of high-quality, consistent studies available is limited, and this topic therefore warrants further research with higher levels of evidence, larger sample sizes, powered outcomes, and longer follow-up times to show the effect or lack thereof of KT. The implications of our review for current clinical practice are that KT is a safe modality, and that despite the lack of evidence to show a clinical benefit following musculoskeletal injury, the athlete may perceive a beneficial effect following KT application.

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SAŽETAK

Kinezi trake se sve više koriste u sportskoj fizioterapiji i posturalnoj rehabilitaciji. Mnogi profesionalni sportisti koriste trake kako bi podržali povređene, izmorene ili prekomerno iskorišćene mišiće. Konstrukcija trake je jedinstvena, ona poseduje visoko elastična svojstva koja angažuju i mišiće i fasciju. Veruje se da KT podržava povređene mišiće i zglobove kao i da oslobađa od bola tako što podiže kožu dozvoljavajući krvni i limfni protok. Cilj ovog preglednog članka je da evaluira, koristeći meta-analizu, efikasnost KT u tretmanu i prevenciji sportskih povreda. Elektronske baze podataka, poput SPORTDiscus, Scopus, MEDLINE, ScienceDirect i sajtovi sportske medicine su pretraživani koristeći ključne reči 'kinezi tejping/trake'. Efikasnost KT u oslobađanju od bola bila je beznalajna s obzirom da nije bilo klinički važnih rezultata. Što se tiče opsega pokreta, dobijeni su neusaglašeni rezultati sa malim korisnim rezultatima, zapaženim u dve studije, mada beznačajni rezultati u druge dve studije za brojne zglobove. Ostvaren je koristan efekat za propriocepciju po pitanju osećaja za grešku u testu sile stiska šake, mađutim, nije bilo pozitivnih efekata za propriocepciju skočnog zgloba. KT su ostvarile znatan efekat na mišićnu aktivnost, mada nije jasno da li su te promene bile korisne ili štetne. Da zaključimo, postoji jako malo kvalitetnih dokaza koji bi podržali korišćenje KT, u poređenju sa drugim tipovima elestičnih traka, u upravljanju ili prevenciji sportskih povreda. KT mogu imati malu korisnu ulogu u poboljšanju sile, opsega pokreta kod određenih povređenih subjekata, kao i u poboljšanju osećaja za grešku, u poređenju sa drugim trakama, mada potrebna su dalja istraživanja koja bi to potvrdila.

Ključne reči: *sportska medicina, kineziterapija, oporavak, atrofija*

FROM TELEMARK TO CARVING

OD TELEMARKA DO KARVINGA

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SUMMARY

Skiing belongs to the group of specific cyclical sports which include the learning, improvement and realization of different motor skills and activities, and as such is inextricably linked to snow-covered terrain at higher altitudes. The exact time when skiing was first invented is unknown, but what is known is that its development throughout history was complex, both in terms of skiing equipment and in terms of technique. The first skis date back to the ice age, 4500 BC, and were of various length, weight and width. Only one ski pole was used. Telemark and Christiania skiing were the basic skiing techniques of turning and stopping which are still being developed and improved to this very day. The position and stances of the skiers have undergone changes and are closely related to ski design and the design of the accompanying equipment. Longer skis of various lengths have been replaced by two shorter skis of the same length, modern automatic buckles, deeper and sturdier ski boots and two shorter identical poles. Competitive skiing has developed and changed in accordance with the requirements of the competition (the carve turns, the length and radius of the skis, their shape, size, the number of and distance between the poles, the quality of the skiing surface, differences in elevation along the ski slope, etc.). A short, heavy and rigid ski was replaced in the 1960's by a more narrow and longer ski, only to be replaced once again during the 1990's by a shorter, more lightweight and wider carving ski. New technological challenges facing the ski industry are once again bound to the more narrow, lightweight and faster skis, but also to the combination of shorter and longer skis which are used in beginner training. Thus, this research deals with the historical representation of current techniques and professional and technical practices in skiing, but also the predictions of future trends in the development of Alpine skiing.

Key words: *skiing, trends, skis, mechanics, development.*

INTRODUCTION

The first record of skiing originates from the regions of what is today known as Norway. It is well known that ancient hunters some 4500 years ago used long and heavy skis to help them navigate their way through impassable, show-covered terrain (Lund, 1996). This period was marked by the emergence of larger societies, a consequence of people's decisions to permanently settle in areas which offered them the possibility to experiment with the cultivation of various plant cultures, which were later considered a staple part of their daily diet. The formation of permanent settlements enabled people to improve and enhance their skiing skills for various purposes. We cannot with any certainty conclude whether people at this time used skis to descend slopes, but their use was gradually becoming more and more frequent. However, we certainly cannot conclude that the origins of skiing should be associated with this period of time. Skiing, in the full sense of the word, occurred much later is only approximately one thousand years old. It is linked to the life and times of the Viking king Harald Hadrada (1046-1066), who promoted the skill of fast skiing as a fun activity aimed at winning and proving one's physical abilities. "Norwegian" skiing achieved its full expansion thanks to mountain farmers, that is, the first Telemark skiers of the Telemark valley, some 80 km from Oslo. The Swedish bishop Olaus Magnus published the book "History of the Northern Peoples" in 1555 in which he described the use of skis for hunting, as well as in competitions held for prizes. The individual most deserving for the affirmation for Telemark skiing was Sondre Norheim (Lund, 1996). His greatest accomplishment was the fact that he made the revolutionary discovery which heralded what are today known as Telemark buckles. Even though, various types of material had been used until then to fasten the foot of the skier to the ski boot, the difference lay in the fact that Norheim's buckle was made of interwoven elastic tree roots. This contributed to the better fastening of the feet to the skis, which directly influenced the development of specific skiing techniques, later known as the Telemark and Christiania techniques (Lund, 1996). In middle Europe skiing was mentioned for the first time in the book of the historian Johann Weikhard von Valvasor "Glory of the Duchy of Carniola" published in 1689 (Kotnik, 2007; Živanović, Savić, Milojević & Milutinović, 2003). The book describes how the Slovenian peasants residing in the region of the mountains of Bloka used their skis solely to make their way around the mountains, and are thus considered the first skiers in the region of middle Europe (Živanović, Savić, Milojević, & Milutinović, 2003).

With the emergence of the carving technique, the development of skiing underwent its full expansion, especially since almost all the differences between recreational and competitive skiing were blurred. Carving as a skiing technique enabled both competitors and recreational skiers to have more stability and to ski much faster on the edges of their skis. In the mid-1990's, more precisely in 1997, a new model of carving skis was designed, whose geometry has persisted to this day. The emergence of carving skis enabled the skier to make a precise turn with their skis, leaving a sharp and clear trace. The fact is that the short, heavy, rigid skis of the 1960's were replaced by more narrow and longer skis, only to once again be replaced by the shorter but more lightweight carving skis in the 1990's. The new technological challenges faced by the ski industry are related to designing more narrow, lighter and faster skis, but also to the combination of shorter and longer skis which could be used to teach beginner skiers.

METHODS

The aim of this paper is to use a historical method of analysis to evaluate skiing practices to date which have directly initiated new trends in the development of Alpine skiing. The historical method represents the basic method of research in historical methodology, which was primarily used in historical research. However, this method can be used in the research as a part of social and natural sciences and as such could be applied in one of the basic research methods in the field of the history of physical education (Savić, 2016). The paper relies on both the historical and descriptive method.

DISCUSSION

New skiing techniques, especially in competitions, are conditioned by the changes in the material which is used to build new skis. The evolution of the Alpine skiing technique increased the demands on the manufacturers of ski equipment to provide a better bond between the skis and skiers. Skiing as a competitive sport began to develop only much later. The first competition in ski traversing and the downhill slalom was held in Christiania (what is today the city of Oslo), where the first ski club was founded. On the occasion of this competition, in 1767, the first ski rules were written. The Telemark region of Norway greatly contributed to the development of competitive skiing. It was precisely there that the brothers Nordheim at the end of the 19th century changed the shape of skis and the buckles. The front and back part of the skis became somewhat wider, and vertical shallow ridges were added to the slick sole so as to enable better control of the direction of ski movement. They were also proficient in the curving technique and stopping technique, which facilitated their movement on skis. The downhill slalom technique, that is, the downhill with poles event emerged at the end of the 19th century, and was first demonstrated by Arnold Lunn. Lunn himself took none of the credit, and instead named Clofield the father of the idea, at the same time being careful not to diminish the influence of Zdarsky, who was a pioneer in invention of a new curving technique, and Schneider, who perfected it (Lunn, 1940). Hannes Schneider is thought to be the father of the revolutionary Arlberg method, which represented the first formalized method of ski training, including movements that ranged from a snow plough turn to a parallel (Corrocher & Guerzoni, 2009). In addition to the slalom, the downhill was also a very popular discipline. The most popular among these competitions was the Challenge Cup organized by Robert of Kandahar, named after the famous British general Frederick Roberts, who led the first great march in Afghanistan, from Kabul to Kandahar (Kennedy & Nicholls, 1981). It is an interesting fact that Roberts himself was not a skier, nor he had ever visited the Alps. The explanation for this can be found in the extensive Victorian sense of patriotism of the time. The popularization of Alpine skiing was considerably promoted by the famous English author Sir Arthur Conan Doyle, the creator of the eccentric detective Sherlock Holmes. In 1894 he crossed the track from Arosa to Davos and published his escapades for posterity in an article in the Strand Magazine, which might be considered the first newspaper account of skiing (Carr, 1975). Competitions were only beginning to be held on organized terrains, and only the beauty of the act of skiing was ever evaluated. In the beginning of the 20^{th} century, artificial obstacles began to be placed on the slope, which were later replaced by thin flexible poles with flags on them. Some time later, a change occurred in the shape of the gates which has remained unchanged until today and gives a common name to this discipline – the slalom. This in turn changed the way in which skiing evaluated. It was no longer the beauty of the run, but instead the time it took to complete the obstacle course along the slope.

This claim is supported by the fact that the technique in the slalom discipline often changed. In addition, one of the main reasons why there was a constant need to improve one's technique was the emergence of flagpoles which allowed the skier to pass through the gates in a completely new fashion (Savić, 2016). All of these changes led the ski schools of the time to change the course of their development, that is, they were forced to adapt to new trends. With an increasing number of competitors all over Europe, there was an increase in the number of new organizations being founded. The first ski associations were founded at the beginning of the 20th century in Switzerland and Germany, along with the ski union of central Europe. The first international ski congress was held in Christiania (Oslo) in 1919. During the first Winter Olympic Games in Chamonix in 1924, the first International Ski Federation was founded *Federation internationale de ski – FIS (Kotnik, 2007)*. Arnold Lunn was given that great honor of being the principal organizer of the first FIS championship in Murren in 1931. (Holt, 1992).

When we look at skiing from the viewpoint of the development of skiing techniques, we can conclude that several different ones are clearly discernible: the Lilienfield, Arlberg, the French rotational, downhill, the Avellment, Jet, balanced skiing without poles, Carving (Jabučanin & Đurović, 2011).

Mathias Zdarsky adapted Nordic skiing and skis to the Alpine terrain. He invented adequate metal buckles which were at the time also known as Lilienfield buckles. He used a long pole to push off and maintain balance (Živanović, Savić, Milojević, & Milutinović, 2003). Zdarsky is considered to be the founder of the snowplough turn. This specific skiing technique is referred to as the Lilienfield technique. Zdarsky was thought to be a great admirer of skiing, and that was probably why he was the first and last Austrian who did not request any monetary compensation for his ski instructing skills (Lund, 1996). On the other hand, Georg Bilgery perfected the skiing technique, which was a "blend" of the Lilienfield and Nordic technique, adapted to suit the Alpine terrains (Živanović, Savić, Milojević, & Milutinović, 2003). Unlike Zdarsky, Bilgery used two poles instead of one to increase a skier's stability. Also, he improved the Lilienfield buckles, which enabled him to improve the current ski technique of the time.

Hannes Schneider was the first professional ski instructor who is considered to be the father of the "revolutionary" Arlberg technique. The basic of this skiing technique was the snow plough turn, to the parallel Christieand the parallel turn. What set Schneider apart from the rest of his predecessors and contemporaries was the introduction of a formalized and methodical training in ski techniques. He provisionally divided the learning process into mutually related wholes, where certain elements of the ski technique were acquired following the principle of an "ascending pyramid", that is, from the simpler ones to the more complex. The basic aim of this approach was to more quickly and efficiently learn ski techniques, for which the training period was significantly reduced. Apart from that, the efficiency and economic nature of the movement, characteristic of the Arlberg technique, enabled an increase in the ski speed, which was especially important for the development of competitive skiing. However, the French school of skiing, with its leader Emile Allais, were staunch opposition to the Arlberg school, considering it too excessive for the turn to begin and end with a snow plough. They believed that a skier from a downhill position should glide and with a turn towards the slope to change the direction of movement. In addition, as is characteristic of this technique, the center of gravity is removed towards the tips of the skis, and when there is a change in direction of movement, the pressure on the back end of the skis is released, so that the movement reminds us of a bucking motion (ruade) (Guido, 1982; Živanović, Savić, Milojević, & Milutinović, 2003).

By mixing the French and Austrian school of skiing, a new technique was founded which increasingly more resembled the modern one, and its founder was Stefan Kruckenhauserfrom

Kitzbühel. He first presented his innovation at the international congress of ski didactics Interskiin 1955 in Val d`Isère (Guido, 1982). It was an accepted fact that turning the body in the direction of the turn was not practical, and that it should be replaced by a turn of the body in the opposite direction to that of the movement of the skis and legs, which enabled a more evenly distributed pressure along the entire ski, as well as an increased stability during the performance of a turn.

Ski equipment also underwent certain changes. The earliest buckles in Alpine skiing did not enable the release of the boots in the case of a fall (Ettlinger & Johnson, 1982). In the 1920's and 30's the ski boot was fastened to the ski with the help of a long cable or a leather belt, which provided the skier with better control of his skis, but due to the inability to release the boots, the skier ran a high risk of injury during a fall or in various situations involving a turn when the influence of force on the skeletal-joint structures increased (Shealy, Geyer, & Hayden, 1974). In the following years, a new buckle was designed which had the ability to release the heel, and not the toes. It was only after 1950 that the first buckle with a release mechanism was designed, based on the same principle that modern buckles operate on today (Natri, Beynnon, Ettlinger, Johnson, & Shealy, 1999). Due to the strong urge to make ski technology more effective and faster, the production of ski buckles was constantly improving, while the construction of skis remained relatively unchanged. Only the greater expansion of ski centers and the construction of ski lifts inspired a series of inventions in ski design. The most innovative idea was the placing of steel rims by an unknown Austrian metal worker in 1928 (Corrocher & Guerzoni, 2009), that is, Harry Oswald Carr in 1932, according to the patent documentation (Carr, 1932), which significantly contributed to the development of ski techniques. With the increase in the ski speed, skis which were built out of a single piece of wood, could not meet the new demands. The production of a complex multi-layered ("laminate") ski in 1939 along with the invention of more effective glues, enabled greater resistance to torsion, which increased the effectiveness of the turn at greater speeds. By 1951, 90% of the manufactured skis were "laminate" (Clark, 1985). Howard Head patented a ski made of composite wood and metal, with a plastic bottom in 1954, which contributed to the development of skis made of "fiberglass" (Head, 1954), which are characterized by their resilience and significantly smaller vibrations at great speeds. By the end of the 1960's, "fiberglass" skis almost completely replaced "metal" ones. In 1990, the Salomon company launched a ski with a single-part plastic "cap" on the tip and sides (Diard & Guers, 1990). At this time skis ranged from 175 to 210 cm in length, and their width was even from beginning to tend. A very important breakthrough in the design of skis was made by the companies Kneissland Elan, which constructed a prototype of a modern carving ski at the beginning of 1990. Due to their wide "tips" and "tails" and narrow "waist" and length of only 160 to 180 cm, these skis were primarily constructed for beginners, since they offered the possibility of an easier turn as the skis would roll onto one edge during a turn. Very soon the competitors also saw that it was much easier to manipulate these skis than the traditional ones, and that at the same time they were more stable when performing a turn at greater speed. The new carving skis very quickly swept through the market and became the standard for all manufacturers of ski equipment (Corrocher & Guerzoni, 2009). In 2012 almost 100 percent of all the skis sold on the market were carving skis (Corrocher & Guerzoni, 2009).

When we view the problem through the prism of competitive and recreational skiing, where competitors tend to ski down the slope at maximum speed, following the ideal – shortest path, in as fluid a manner as possible, without extensive effort or exertion, we can undoubtedly conclude that the modern carving skis have met all the requirements. The entire history of Alpine skiing was focused on change and improvement in technique, with alterations in ski equipment. The tendency was to enable the competitors to achieve maximum speed, and the recreational skier's complete security, that is, comfortable and

quick learning, and thus maximum enjoyment of the snowy slopes with a simple, easy to learn means of achieving the skill of skiing.

The carving skis are specific in terms of appearance, of different geometry in comparison to the traditional skis, wider and significantly smaller in length. With these significant changes, it was easier to ski and to maneuver, so the training of future skiers was adapted to suit the new ski geometry, and the skiers were made to adapt to new situations surrounding skiing more efficiently and more quickly. Carving skills today also help recreational skiers to ski relying on approximately the same technique as competitors. Of course, there is a big difference in the technique in performing the turn, but a properly performed turn enables a unique sense of skiing. Even though the "first" model of the carving skis was presented in 1997 (Elan company, Begunje, Slovenia), the idea originated much earlier. By analyzing the patent documentation, we found a certain patent which was granted in 1950 (Louis, 1950). The author points out that the basic idea behind this patent is for the skier not to be burdened by constantly guiding the skis, because the skis with their geometric make-up will be able to provide greater resistance and adhere more closely to the surface of the snow. This enables the skis to be more stable during the performance of a turn with a small radius when compared to more conventional skis. Furthermore, the authors Droste and Strotmann very vividly described the "structured" Telemark skis in their book, which were still being produced until 1940. According to these authors, the designer of the first carving ski was Sondre Norheim, who was quite ahead of his time with his radical ideas (Corrocher & Guerzoni, 2009; Droste & Strotmann, 2003).

CONCLUSION

Finally, it is clear that as early as the end of the 19th and the beginning of the 20th century there was great enthusiasm for the development of skiing. This of course included that the development of ski techniques, whose pioneers included Sondre Norheim, Mathias Zdarsky, Arnold Lunn and Hannes Schneider, and which had to develop at the same time as the ski industry, without which skiing as a sport and the recreational activity of many would certainly not be where it is now. The design of the first Telemark buckle provided unity between the body of the skier and the skis, which led to a greater stability and was the first precondition for the immediate development of the ski technique. The design of a buckle with a release mechanism reduced the risk of injury. The skis themselves also underwent significant changes, from skis made out of a single piece of wood, to those made from various composite materials, which contributed to the greater stability and smaller vibrations of the skis when making a turn at great speed. With the launch of the carving skis, skiing underwent a true revolution. Carving skis enabled each skier better control of the turn in various conditions and at various speeds. On the other hand, the training of beginners was significantly reduced and made easier, so that almost anyone could master the carving turn, which contributed to a greater enjoyment of the skiers and thus led to the increased popularity of skiing. Skiers in the Alpine disciplines achieve great speeds on various types of terrain which requires quick and forceful adaptation. Moreover, skis also function as levers, and in the best sense could represent an extension of the muscle-skeletal system of the body, and in the worst case, a mechanism which could trigger numerous sports injuries. We assume that future trends will lead to the development of equipment which will be as efficient and economic as possible, and which would allow skis to become more popular. Having said this, we are of the opinion that skis will be narrower, more lightweight and faster, which will undoubtedly contribute to better competitive results but also enable recreational skiers greater enjoyment.

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SAŽETAK

Skijanje spada u specifične ciklične sportove koji u sebi sadrži učenje, usavršavanje i realizaciju različitih motornih veština, radnji i kao takav je tesno povezan sa snežnim površinama na većim nadmorskim visinama. Ne zna se tačno kada je skijanje nastalo, ali zna se da ima bogat i sveobuhvatan istorijski razvoj, kako u delu opreme tako i u delu tehnike. Prve skije datiraju još iz perioda ledenog doba 4500. g.p.n.e. i bile su različitih dužina, teške i široke. Koristio se samo jedan štap. Telemark i Kristijanija bile su osnovne skijaške tehnike skretanja i zaustavljanja skijaša koje se evidentno i dan danas razvijaju i usavršavaju. Položaj, stav i pozicija skijaša doživeli su promene i usko su vezani za dizajn skija i prateću opremu. Dugačke skije različitih dužina zamenile su dve kraće skije istih dužina, savremeni automatski vezovi, dublje i tvrđe cipele i dva kraća identična štapa. Takmičarsko skijanje razvijalo se i menjalo u skladu sa zahtevima takmičenja (tehnika zavoja, dužina i radijus skija, oblik, veličina, broj i međusobni razmak štapova za kapije, kvalitet podloge, visinska razlika staze, itd.). Kratku, tešku i tvrdu skiju zamenile su šezdesetih godina uže i duže skije, da bi devedesetih njih ponovo zamenila kraća, ali lakša i šira karving skija. Novi tehnološki izazovi ski-industrije vezuju se ponovo za užu, lakšu i bržu skiju, ali i za kombinaciju kraće i duže skije u obuci početnika. Dakle, istraživanje se bavi istorijskim predstavljanjem dosadašnjih tehnika i stručne prakse u skijanju, ali i predviđanjima budućih trendova u razvoju alpskog skijanja.

Ključne reči: *skijanje, trendovi, skija, tehnika, razvoj*


GUMAR
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