

JUDO, SOCCER AND TRACK-AND-FIELD DIFFERENTIAL EFFECTS ON SOME ANTHROPOLOGICAL CHARACTERISTICS IN SEVEN-YEAR-OLD BOYS

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Abstract:

In this paper we studied the effects of nine months of physical training by comparing seven-year-old boys participating in the 9-month-training in soccer, track-and-field and judo, with non-additionally physically engaged same-aged controls. The experimental programmes consisted of additional 45-minute exercise routines 3 times weekly. The morphological measures, motor-endurance changes and differences were studied. No significant differences were found between the groups at the study's onset, except in the 20m dash, where the track-and-field group was superior to the control group. All the experimental programmes led to significant improvements in some anthropological characteristics among the participants compared to the control group. In conclusion, it is difficult to rank the experimental programmes in terms of multidimensional implications on some anthropological characteristics. It is much more appropriate to conclude that each programme had a specific influence on the variables of some anthropological characteristics that are highly important in a particular sport.

Key words: motor abilities, morphology, experimental programmes

Introduction

One of the main interests in exercise science is the influence of the different sport training programmes on the different anthropological features of humans, especially during the childhood period (Babin, Katić, Ropac, & Bonacin, 2001; Katić, Maleš, & Miletić, 2002; Katić, Bonacin, & Blažević, 2001; Sekulić, Krstulović, Katić, & Ostojić, 2006; Violan, Small, Zetaruk, & Micheli, 1997). This is mostly obvious in motor and morphological features since these characteristics are highly important in learning and improving different movement structures. Studies dealing with such problems mostly require a follow-up approach and are additionally complicated if prepubescent children are studied, since inclusion in the school system rapidly decreases physical activity in children (Baranowski, Thompson, Durant, Baranowski, & Puhl, 1993; Dollman, Norton, & Tucker, 2002). The question that arises is how much a 5-to-7-hour daily sedentary activity negatively influences some anthropological characteristics of boys. It has been proven that different types of physical exercise influence some anthropological characteristics differently in prepubescent children (Katić, et al., 2002; Sekulić, et al., 2006; Malina, Bouchard, & Bar-Or, 2004; Malina, Eisenmann, Cumming, Ribeiro, & Aroso, 2004; Serbescu, et

al., 2006). Therefore, the presumption was that the sports analysed in this paper (track-and-field, soccer and judo) would significantly, but in a different way, influence some anthropological characteristics of seven-year-old boys. We hypothesized that soccer training (S) would improve cardiovascular endurance, agility and speed in seven-year-old boys, as has already been shown in children aged 13 to 15 (Malina, et al., 2004). Additionally, based on previous studies among seven-year-old girls (Katić, et al., 2002), track-and-field (T-F) should significantly impact on strength, endurance, and coordination, but there have been no previous investigations concerning seven-year-old boys. Finally, since the effects of 9 months of judo training (J) were already presented (Sekulić, et al., 2006), J can be considered as a valuable programme in (a) improving agility and muscular endurance, as well as (b) keeping subcutaneous fatty tissue to the same level as at the study's onset (inclusion in the first grade of elementary school). In most of the mentioned experiments, as in the study of Violan, et al., (1997) the results of the experimental programmes (E, training groups) were compared to those of the less systematically physical engaged controls (C). There is no doubt that the data and conclusions of the briefly reviewed previous study

and other similar studies (Babin, et al., 2001; Katić, et al., 2002; Katić, et al., 2001; Andersen, 1994; Rowland, 1996; Viru, et al., 1998) reveal important findings regarding the effects of physical exercise on youngsters. Nevertheless, we are of the opinion that most of the conclusions derived from these experiments were somewhat expected since E additionally exercised and C participated exclusively in a physical education (PE) curriculum (except in the study of Sekulić, et al., (2006) where C and E were additionally physically engaged). Thus, we can summarize that most of the fitness changes in prepubescent schoolchildren are highly dependent on their engagement in physical training.

Therefore, the aim of the present study was to analyse and compare the influence of three E 9-month training programmes (J, T-F, S), and a C programme (PE exclusively) on the coordination, agility, flexibility, muscular endurance, cardiovascular endurance, and body composition (subcutaneous fatty tissue) in seven-year-old boys who had, with no previous sports experience.

Methods

Subjects and experimental design

All the subjects (N=202, mean age $7.1 \pm .4$ years) were first graders, and their parents had given their informed consent for the study programme and testings. Only those subjects who participated in the 90 training sessions (90% of the total 100 sessions) were included in the study. The control group (C) consisted of boys (n=55; mean age $7.2 \pm .3$ years), who participated in regular PE classes 3 times a week (45 minutes per session), for 9 months. The C program initially involved 71 subjects. Seven of them (10%) dropped out during the course of the study, while 10 boys (14%) participated in fewer than 90 training sessions and were not observed in this study.

It must be stressed that the most important part of each training session/class in the E and C groups was play. The PE curriculum was conducted by PE teachers, and each class consisted of the following: (1) *Introduction* – various running exercises and/or simple dynamic games – 4 to 5 minutes; (2) *Preparatory* part – preparation of the whole locomotor system - 7 to 8 minutes; (3) *Main part 1* - different fundamental motor skills (running, rolling, crawling, hopping, jumping, etc.) and elementary gymnastic elements - 15 to 18 minutes; (4) *Main part 2* – different elementary games – 10 to 12 minutes; and (5) *Cooldown, relaxation and stretching* – 4 to 5 minutes.

The E groups consisted of boys who participated in additional experimental programmes in judo, soccer or track-and-field, apart from PE. All E programmes were organized 3 times weekly (45-minutes class), during a 9-month period. The

experimental groups (E) included boys (n=41; mean age $7.2 \pm .3$ years) who voluntarily chose judo (J) (n=68; mean age $7.0 \pm .6$ years), track-and-field (T-F) (n=38; mean age $7.1 \pm .4$ years) or soccer (S) and participated in a nine-month programme.

When observing all three E groups, 10% of the boys dropped out during the course of the study, while 17% participated in fewer than 90 training sessions and were not observed in this study.

Except for clinical health and free will, there were no additional criteria for inclusion into the E programme. Each E group had the same instructor for 9 months. The E programmes were similarly arranged, and they differed in the main parts of the class. In short, the structure of the classes is presented as follows:

1. warm-up included (similarly in all E groups):
 - o different fundamental motor skills (running, rolling, crawling, hopping, jumping, etc.) – 4 to 5 minutes;
 - o foot/ankle rotation, extensions and flexions; knee rotation and squats, leg kicks and rotation of the hips, trunk/waist rotation; shoulder/arm rotation, neck rotation, etc. – 3 to 4 minutes;
 - o elementary gymnastic elements – 4 to 5 minutes;
 - o flexibility training (passive and active stretching; proprioceptive neuromuscular facilitation techniques) – 3 to 5 minutes;
- 2a) main part of the training session (judo):
 - o study and practice of judo elements (postures – *shisei*; grips – *kumi kata*; movements – *shintai*; falls – *ukemi waza*; throws – *nage waza*; lying techniques – *ne waza*; free play or sparring – *randori*) – 15 minutes;
 - o elementary judo, wrestling, and other combat-related games – 10 minutes;
- 2b) main part of the training session (track-and-field):
 - o the basis of the track-and-field movement skills: running, throwing, jumping – 10 minutes;
 - o track-and-field-based obstacle courses and relays – 15 minutes;
- 2c) main part of the training session (soccer):
 - o fundamental and elementary soccer skills (specifics of walking and running in soccer, starts, jumps, hoops), and elementary ball drills (dribbling, passing, kicking the ball, etc.);
 - o soccer obstacle courses and simplified soccer-based games;
3. cooldown, relaxation and stretching – 5 to 8 minutes (almost identical in all E programmes).

All the subjects were tested twice: before the beginning of the E and C programmes (I), and at the end of the 9-month programme (F).

Variables

The variables included body weight (BW; measured in .1 kg), body height (BH; measured to the nearest .5 cm), the sum of two skinfolds (SUM2SF; triceps and subscapular; .1 mm), and 10 motor endurance tests (Katić, et al., 2002; Bompá, 1998; Cureton, 1982). Coordination was tested using a simple 10m obstacle course test, which includes backward crawling (A) over and (B) under 35-cm-high obstacles placed (A) 3 metres and (B) 6 metres from the start line (OBSTACLE; .1 s); agility - using the 4 x 1.98m shuttle run test (SHUTTLE; .1 s); flexibility, by maximal circumduction of both shoulders while holding a measuring stick with both hands fully extended, with a smaller distance between palms denoting a better result (FLEX-SH; 1 cm) and a sit-and-reach test (SIT-REACH; 1 cm); speed, by an electronically timed 20m dash (20M; .01 s); explosive power, by a standing long jump (L-JUMP; 1 cm) and distance overhand softball throw (THROW; 10 cm); muscular endurance, by flexed arm hang (HANG; 1 s), and 90-degree flexed-knee sit-ups performed in one minute (SIT-UP); and aerobic endurance, by a 3-minute running (ENDUR; running distance measured to the nearest 5 metres).

BW was measured with a digital scale (the participants wore shorts and no shoes), BH (at maximum inspiration) with a measuring scale mounted on the wall, and the skinfolds using a Lange calliper. All the measurements were collected by experienced evaluators (Maleš, Sekulić, & Katić, 2004; Sekulić, Viskić-Štalec, & Rausavljević, 2003).

All the tests (except for HANG, SIT-UP and ENDUR) were performed three times, with an appropriate rest period in between. The mean of the three scores was used in the analysis. For the multiple-item tests the Cronbach's alpha ranged from .79 (SHUTTLE) to .96 (SIT-REACH) in the motor tests, and .79 (subscapular skinfold) to .96 (BW) in the morphological tests. For the single-item variables, the test-retest correlation coefficients (initial-final correlations) were above .85 for the C group, .89 for the ET-F group, .88 for the EJ group and .85 for the ES group, for each group separately, all defining acceptable to high intraobserver reliability of the tests.

Statistical analysis

The descriptive statistics for all groups were calculated separately (means - M; standard deviations - SD). To establish the simple quantitative differences between (A) the initial and final measurement, and (B) the C group and E groups in the initial and final measurement, we used the repeated measures analysis of variance (ANOVA), with the *post-hoc* comparisons using the Scheffé's test. For a detailed analysis of the achieved changes between F and I, we performed the one-way ANOVA on the variables

of the final-initial single measure differences, that is, we first calculated the differences within each of the measured variables ($x_{\text{diff}} = x_{\text{final}} - x_{\text{initial}}$). Then, using the so-calculated variables (variables of the differences), we performed the analysis of variance using the C - E criterion (Violan, et al., 1997; Maleš, et al., 2004). All the coefficients were considered significant at $p < .05$. Statsoft's Statistica software was used for all statistical procedures.

Results

The Cronbach's alpha coefficients for all variables exceeded .92, which confirmed a high level of item consistency.

With the exception of the 20m dash, the groups did not differ significantly at the study onset (Table 1). In the 20m dash, the T-F group significantly dominated over the C group.

All three E groups improved significantly in all analysed variables (except for the sum of two skinfolds) in the initial and final testing, and so did the C group (except in SHUTTLE). A significant decrease in the sum of two skinfolds (6%) was found in the S group, while a significant increase (12%) in the same variable was found in the C group.

Contrary to the results of the initial testing, significant differences between E and C were observed in the final testing. In particular, the sum of two skinfolds was significantly higher in C, while the E groups achieved better results in practically all the analysed variables.

Since the increase in the sum of two skinfolds (observed in the C group only) negatively influences most of the motor-endurance variables (Katić, et al., 2002; Rowland, 1996; Cureton, 1982; Maleš, et al., 2004), we additionally performed the ANOVA with statistically controlled differences in the sum of two skinfolds between the groups in the final measurement. Briefly, apart from having only negligible changes in statistical significance, the groups differed significantly in the same variables as in the "non-controlled" approach.

When comparing the E groups for changes between initial and final testing results (Table 2), it can be observed that T-F and S showed greater improvement than the J group in the 3-minute running, distance overhand softball throw, and 20m dash.

On the contrary, the J group achieved better results in the HANG and SIT-UP, as well as in SIT-REACH tests, when compared to S and T-F. Finally, comparing the T-F and S groups, T-F achieved significantly better results in L-JUMP, while in S group the sum of two skinfolds was significantly reduced and aerobic endurance was significantly increased.

No significant differences in body height and body weight were found between the C and E groups (Table 1). Therefore, the non-significant differences

Table 1. Descriptive statistics in the initial and final measurement (means and standard deviations - SD); initial-final percent changes; ANOVA significance (Initial and final differences: ^a $p < .05$; Control – Experimental differences: * $p < .05$)

VARIABLES	CONTROL GROUP (C)			EXPERIMENTAL GROUP (S)			EXPERIMENTAL GROUP (T-F)			EXPERIMENTAL GROUP (J)		
	INITIAL	FINAL	Change	INITIAL	FINAL	Change	INITIAL	FINAL	Change	INITIAL	FINAL	Change
	Mean±SD	Mean±SD	%	Mean±SD	Mean±SD	%	Mean±SD	Mean±SD	%	Mean±SD	Mean±SD	%
BH (cm)	128.3±4.6	131.7±5.5 ^a	3%	128.7±5.8	132.2±6.1 ^a	3%	129.0±4.8	132.4±4.9 ^a	3%	127.4±4.3	131.2±4.6 ^a	3%
BW (kg)	27.0±3.8	29.8±3.5 ^a	10%	27.5±5.2	29.0±5.5 ^a	5%	27.3±3.7	29.0±3.6 ^a	6%	27.7±3.9	29.9±4.7 ^a	8%
SUM2SF (mm)	17.1±4.9	19.1±4.8 ^a	12%	16.2±6.3	15.3±5.8 ^{a*}	-6%	16.0±3.7	15.8±3.3 [*]	-1%	16.6±5.1	16.4±5.7 [*]	-1%
SIT-REACH (cm)	36.2±7.7	41.0±6.9 ^a	13%	36.3±10.5	45.0±10.3 ^{a*}	24%	33.4±7.4	41.6±8.4 ^a	25%	34.3±7.4	45.8±8.4 ^{a*}	34%
FLEX-SH (cm)	55.1±8.0	49.6±6.6 ^a	11%	53.8±6.6	50.1±6.6 ^a	7%	54.2±9.3	50.9±8.6 ^a	6%	54.7±8.2	49.9±9.4 ^a	10%
OBSTACLE (s)	18.1±2.6	16.2±3.5 ^a	12%	17.1±3.8	15.4±3.2 ^a	11%	18.4±3.9	16.7±3.2 ^a	10%	17.2±3.2	15.7±3.4 ^a	10%
SHUTTLE (s)	15.0±2.1	14.8±2.9	1%	14.1±1.6	12.6±1.2 ^{a*}	12%	13.8±1.2	12.4±1.2 ^{a*}	11%	14.1±1.5	12.8±1.2 ^{a*}	10%
L-JUMP (cm)	120.1±17.0	130.0±13.8 ^a	8%	122.6±15.6	135.0±13.0 ^a	10%	121.4±11.1	137.5±12.5 ^{a*}	13%	116.9±13.2	133.6±15.7 ^a	14%
THROW (m)	10.4±2.9	12.1±4.1 ^a	16%	9.4±1.8	11.7±1.8 ^a	24%	10.0±2.9	14.1±3.8 ^{a*}	41%	9.4±2.5	11.5±3.2 ^a	22%
20M (s)	4.9±1.3	4.6±1.6 ^a	7%	4.7±1.5	4.3±1.4 ^{a*}	9%	4.8±1.3 [*]	4.3±1.2 ^{a*}	12%	4.8±1.4	4.5±1.3 ^a	7%
SIT-UP (f)	21.9±7.6	26.6±6.1 ^a	21%	25.2±6.2	28.9±6.0 ^a	15%	24.6±7.8	29.3±5.7 ^{a*}	19%	23.6±6.1	30.7±6.3 ^{a*}	30%
HANG (s)	11.9±7.1	16.0±11.3 ^a	34%	13.7±10.8	19.3±12.7 ^a	41%	14.6±9.0	20.9±10.8 ^a	43%	13.6±11.94	23.4±13.8 ^{a*}	72%
ENDUR (m)	500.7±59.9	515.9±65.4 ^a	3%	505.9±70.8	558.8±71.0 ^{a*}	10%	504.3±72.6	545.1±74.0 ^{a*}	8%	503.15±39.92	523.5±54.1 ^a	4%

Legend: body weight (BW), body height (BH), sum-of-two-skinfolds (SUM2SF), backward crawling (OBSTACLE), shuttle run test (SHUTTLE), flexibility (FLEX-SH), sit-and-reach test (SIT-REACH), 20m dash (20M), long jump (L-JUMP), softball throwing (THROW), flexed arm hang (HANG), sit-ups (SIT-UP), 3-minute running (ENDUR).

S – soccer, T-F – track and field, J – judo

Table 2. Descriptive statistics (means and standard deviations - SD) ; ANOVA significance of the variables of the differences between the final and initial measurement for the control and experimental groups (* $p < .05$)

VARIABLES	S F - I	T-F F - I	J F - I	T-F/J	J/S	T-F/S
	Mean±SD	Mean±SD	Mean±SD	ANOVA	ANOVA	ANOVA
BH (cm)	3.5±1.2	3.4±.9	3.8±1.0	3.2	1.9	.04
BW (kg)	1.5±.8	1.8±.9	2.3±1.2	7.1 ^{J*}	11.8 ^{J*}	2.3
SUM2SF (mm)	-.9±.7	-.2±1.0	-.2±2.1	.00	3.8	12.9 ^{S*}
SIT-REACH (cm)	8.6±3.9	8.1±4.6	11.5±7.6	8.4 ^{J*}	4.3 ^{J*}	.3
FLEX-SH (cm)	-3.7±2.1	-3.3±4.5	-4.8±7.2	1.8	.7	.3
OBSTACLE (s)	-1.7±1.3	-1.8±1.6	-1.5±2.7	.59	.2	.1
SHUTTLE (s)	-1.5±.8	-1.4±.9	-1.3±1.1	.33	1.3	.6
L-JUMP (cm)	12.3±8.5	16.1±8.0	16.6±14.1	.09	2.8	5.2 ^{T-F*}
THROW (m)	2.3±.8	4.1±2.6	2.1±2.2	16.8 ^{T-F*}	.2	17.9 ^{T-F*}
20M (s)	-.5±.3	-.5±.2	-.3±.3	7.7 ^{T-F*}	15.2 ^{S*}	1.5
SIT-UP (f)	3.8±1.4	4.7±4.2	7.2±5.1	9.1 ^{J*}	7.8 ^{J*}	.5
HANG (s)	5.6±4.6	6.3±5.1	9.8±13.0	11.4 ^{J*}	6.6 ^{J*}	.01
ENDUR (m)	52.9±21.5	40.7±27.3	20.3±34.2	11.7 ^{T-F*}	25.2 ^{S*}	5.6 ^{S*}

Legend: body weight (BW), body height (BH), sum-of-two-skinfolds (SUM2SF), backward crawling (OBSTACLE), shuttle run test (SHUTTLE), flexibility (FLEX-SH), sit-and-reach test (SIT-REACH), 20m dash (20M), long jump (L-JUMP), softball throwing (THROW), flexed arm hang (HANG), sit-ups (SIT-UP), 3-minute running (ENDUR).

F – I (differences between the final and initial measurement)

S – soccer, T-F – track and field, J – judo

T-F/J - univariate significance of the variables of the differences between track-and-field and judo experimental groups

J/S - univariate significance of the variables of the differences between soccer and judo experimental groups

T-F/S - univariate significance of the variables of the differences between track-and-field and soccer experimental groups

in body height and body weight between the C and E groups (Table 1) can be considered as an important methodological advantage in further discussion.

Comparing the results observed in this study with those of some previously published studies, we find that: (a) the average body height and body weight results of the subjects in our study are negligibly higher than the values presented by the USA Center for Disease Control and Prevention (Malina, et al., 2004); and (b) the initial similarity of our sampled subjects with age-related subjects lies in the muscular endurance and power variables (Babin, et al., 2001; Katić, et al., 2001; Malina, et al., 2004; Malina & Moriyama, 1991).

Discussion and conclusions

The obtained results partially confirm the hypothesis investigated. The experimental programmes compared had different and unique impacts on anthropological characteristics in seven-year-old boys. The main objectives and conclusions of our study are discussed in detail in the following paragraphs.

Control-experimental differences at the study's onset

As specified, only the 20m dash significantly differentiated the groups in the initial testing. Several factors influenced such a result. Firstly, all the subjects were sampled from three schools in the same urban district, so there is a high probability that their general eating habits and lifestyles (especially the time spent outdoors) were somewhat similar. Secondly, the sample we studied consisted of seven-year-old boys who did not participate in any kind of organized sport, which significantly reduced the likelihood of differentiation in some physical fitness variables. Finally, the E programmes were randomly offered in different schools, but only one programme was available in each school, which practically inhibited the boys in choosing the sport they were more inclined to engage in (e.g., stronger boys would probably choose judo and/or faster boys would probably choose track-and-field). The reason for the significant differences between T-F and C in the 20m dash presumably lies in the problem of statistical significance. Briefly, since T-F group was larger than the other groups, it allowed the numerical differences in 20m results (observable but not significant in all the E groups when compared to C) to reach an acceptable level of significance.

Analysis of fitness changes in the 9-month period

Growth and development naturally led to a significant improvement in BW and BH for all groups. However, it is noteworthy that the SUM2SGF increased exclusively in the C group.

Since the numerical (even significant in the S group) decrease in SUM2SF is evident, it can be concluded that 3-times-weekly 45-minute organized physical exercise (in PE class), does not prevent body fat increase in seven-year-old boys, a problem that has already been recognized in some previous studies (Babin, et al., 2001; Katić, et al., 2002).

Contrary to the morphological measures, a significant improvement in motor fitness is evident for all the variables in all the groups of subjects. The improvement was expected and happened due to (a) growth and development (Babin, et al., 2001; Katić, et al., 2002; Katić, et al., 2001), and (b) probably because of the additional exercise in E groups. Generally, I-F changes do not allow one to answer the question regarding any possible differential effects of the three experimental programmes in seven-year-old boys. The following analysis will explain the problem more clearly.

Control-experimental differences at the end of the 9-month-period

Considering the results of the previous analysis, it was expected that significant differences in SUM2SF between the E groups and C group would appear. The result is a logical consequence of the relative physical inactivity of the C group, when compared to the E groups, during the 9-month period.

The S and C groups significantly differed in flexibility, agility, speed and aerobic endurance. Since flexibility is one of the motor dimensions that can be easily developed through training programmes (Alter, 2004), improvements in the flexibility variables were expected. From the brief descriptions of the E training programmes, it is evident that 3-5 minutes of training was aimed at enhancing flexibility. Since flexibility regularly decreases in boys from ages 5 to 12 years (Malina, et al., 2004), it is encouraging that we were able to establish a relatively large improvement in flexibility in all three E groups, although the training programme was relatively low-volume.

Different types of short and long distance running exercises, including various obstacle courses, significantly influenced aerobic endurance in the S group. Previous research indicates that sports like soccer are very useful in improving agility (Erceg, Zagorac, & Katić, 2008), which was directly confirmed in our study. Knowing that genetics plays an important role in speed (running speed improves sharply from 5 to 8 years of age (Malina, et al., 2004), the significant improvement in 20m dash for S has to be partially explained by an improvement in the running technique (they exercised and performed running techniques regularly), and not exclusively by an improvement in speed. Additionally, the S group played soccer for 10-15 minutes each training session, which gave them the proper stimulus for the improvement in aerobic endurance by up to 10%.

Although aerobic endurance is highly dependent on the physical-training engagement (Annesi, Westcott, Faigenbaum, & Unruh, 2005), some of the improvements in the ENDUR test results have to be explained by a decrease in SUM2SF, since it is well known that body fat percentage significantly influences running economy (Rowland, 1996; Cureton, 1982; Maleš, et al., 2004; Norman, et al., 2005).

Based on the results of our study (Table 1) track-and-field programme had greater influence on the motor fitness of the subjects than did J and S. Thus, at the end of the study, the subjects in the T-F group differed significantly from C in agility (SHUTTLE), explosive power (L-JUMP and THROW), speed (20M), and muscular and aerobic endurance (SIT-UP; ENDUR). Such a result has to be partially attributed to the standard track-and-field elements (e.g., throwing, jumps and/or running) which were regularly applied during the course of the T-F programme. Those elements are also integral parts of some of the testing procedures that we used in our study. In other words, the T-F group was able to practise the exact motor skills that our built-in tests measured for the purpose of defining motor status in our study. Additionally, there is no doubt that T-F has to be considered as valuable training method in improving the motor abilities of seven-year-old boys (Katić, et al., 2002), but we are of the opinion that some of the I-F differences have to be explained by previously stated test specificity. Finally, the significant differences between T-F and C in the 20m dash test have to be considered in relation to the significant differences in the same variable in the initial measurement.

The significant differences between J and C in the F measurement of flexibility have to be explained in view of the high trainability of such a motor dimension (see previous text). Although we expected S and T-F to influence agility significantly, it was the J training that improved agility significantly as was the case in some previous studies (Sekulić, et al., 2006). The increase in abdominal muscular endurance in the J group can be attributed to the lying techniques (*ne waza*) and sparring (*randori*), which consist of elements that indirectly strengthen the abdominal muscles (Sekulić, et al., 2006). Biomechanically, the dominance of the E group in the HANG variable is relatively easy to explain, considering that all judo duel elements such as gripping techniques, are anatomically highly comparable to the HANG test.

Initial-final amount of changes in E groups

Significant differences between J, and the other two E groups were observed in BW, SIT-REACH, SIT-UP and HANG; all the differences were in favour of the J group. On the other hand, T-F and

S showed greater improvement in speed (20M) and aerobic endurance (ENDUR), and T-F additionally dominated in THROW. The J group's superiority in muscular strength and endurance is a natural consequence of the frequently practised judo lying techniques and sparring. Although previous studies did not confirm the influence of strength training on body composition in prepubescent boys (Malina, 2006), it seems that improvement in strength is followed by parallel hypertrophy, since BW increased significantly in the J group, and no significant I-F changes were found in SUM2SF and BH.

Compared to track-and-field and soccer training, judo is superior because of the more dynamic movement patterns, especially dynamic bows, extensions, flexions, and rotations of the torso. Such patterns directly influenced the range of motion of some body parts and joints. In other words, although all the E programs consisted of equal flexibility training programmes during the warm-up and introduction in each exercise session (see Methods), the judo training programme provides far better opportunities for improving flexibility in the main part of each exercise session compared to T-F and S. Therefore, it is not surprising that the improvement in flexibility was more pronounced in J than in the other two E groups.

We previously discussed some factors that may have led to the differences between the T-F and C group in 20M, ENDUR and THROW. Therefore, there is no doubt that such logic should be followed when comparing the amount of changes in those variables between T-F and J.

On the other hand, ES to J dominance in speed (20M) and aerobic endurance (ENDUR) is probably the logical consequence of (a) the influence of the characteristic training drills and cardiovascular workout regularly performed during the S programme (Al-Hazzaa, et al., 2001; Arnason, et al., 2004), and (b) some improvement in the running technique, which additionally ensured better results in S.

The amount of decrease in SUM2SF was larger in S than in the T-F group. Such difference is probably related to the greater increase in aerobic endurance (ENDUR) in S than in T-F. In other words, S group regularly performed moderate tempo and intensity running, mostly throughout the soccer game. This directly influenced the increase in ENDUR, while affecting the reduction in SUM2SF.

Finally, boys continuously improve their capabilities in explosive power until 18 years of age (Malina, et al., 2004). Previous studies performed on twin pairs suggested that during the growth period explosive power is under a moderate to moderately strong genetic influence (Beunen, et al., 2003). Therefore, the significant improvement in L-JUMP and THROW for T-F compared to the S

group was partially expected, especially considering the effects of the throwing and jumping exercises regularly performed in the T-F.

Based on the results presented and discussed herein, the following conclusions can be drawn:

- The three applied training programmes differently influenced some anthropological characteristics of seven-year-old-boys, depending on the various characteristics of each of the sports performed. This is particularly interesting since the E programmes differed solely in the main part of each 45-minute training session.
- All E programmes resulted in some improvement in some anthropological characteristics compared to C programme, which consisted only of a regular PE curriculum.
- It has to be noted that boys participating in a PE curriculum, with no additional physical exercise, increased their body fat percentage significantly during the course of the 9-month study (one school-year).
- A nine months of soccer training (ES) performed 3-times/week is highly efficient in reducing body fat percentage, and increasing flexibility, agility,

speed and aerobic endurance in seven-year-old boys.

- A nine month athletic training (EA) performed 3-times/week is highly efficient in improving agility, explosive power, speed, muscular and aerobic endurance.
- Nine months of judo training (EJ) performed 3-times/week is highly efficient in improving flexibility, agility and muscular endurance in seven-year-old boys.
- Accordingly, it is difficult to rank the experimental programmes in terms of their multidimensional implications on some anthropological characteristics. It is much more appropriate to conclude that each programme had a specific influence on the variables of some anthropological characteristics that are highly important in the particular sport that was performed.
- Since we compared specialized E programmes in the sample of boys, further studies have to be conducted to compare the effects of the different specialized sports training programmes on some anthropological characteristics of girls.

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RAZLIKOVNI UČINCI TRENINGA JUDA, NOGOMETA I ATLETIKE NA ANTROPOLOŠKA OBILJEŽJA SEDMOGODIŠNJIH DJEČAKA

U ovom istraživanju analiziran je utjecaj tri različita devetomjesečna eksperimentalna programa (nogomet, atletika i judo) i kontrolnog programa (redovita nastava TZK) na koordinaciju, agilnost, fleksibilnost, mišićnu i aerobnu izdržljivost, te potkožno masno tkivo kod sedmogodišnjih dječaka bez dotadašnjeg sportskog iskustva. Svi su ispitanici testirani dva puta (inicijalno i finalno), a treninzi su se provodili tri puta tjedno u trajanju od 45 minuta. Primijenjena je analiza varijance (ANOVA) s post-hoc usporedbom pomoću Scheffe's testa te je izračunata univarijatna analiza varijance razlika (*one-way ANOVA*) srednjih vrijednosti rezultata među skupinama od inicijalnog do finalnog mjerenja za morfološke i motoričke varijable. U inicijalnom je mjerenju utvrđeno da nema značajnih razlika u primijenjenim varijablama između skupina, osim

u testu *sprint na 20m* i to u korist eksperimentalne atletske skupine u odnosu na kontrolnu skupinu ispitanika. Ispitanici sve tri eksperimentalne skupine postigli su značajan napredak u nekima od primijenjenih antropoloških varijabla u usporedbi s kontrolnom skupinom. Zaključno, nije moguće precizno rangirati primijenjene eksperimentalne programe prema kriteriju višestranog utjecaja na razvoj motoričkog statusa kod sedmogodišnjih dječaka. Primjereno je zaključiti da je svaki eksperimentalni program imao specifičan utjecaj upravo na one sposobnosti koje su bitne za uspjeh u tom sportu.

Ključne riječi: motoričke sposobnosti, morfolologija, eksperimentalni programi