Coll. Antropol. 39 (2015) 1: 131–143
Original scientific paper

Differences in Physical Fitness among Young Tennis Players in between 1992 and 2008

Aleš Filipčič[1], Tjaša Filipčič[2] and Bojan Leskošek[1]

[1] University of Ljubljana, Faculty of Sport, Ljubljana, Slovenia
[2] University of Ljubljana, Faculty of Education, Ljubljana, Slovenia

A B S T R A C T

The aim of this study was to find a trend of changes for selected anthropometric characteristics and motor abilities of young male and female tennis players of three different age groups. Trends were observed in the periods between 1992, 2000 and 2008. In addition, a comparison of results of tennis players and school pupils was included. The sample of subjects were selections of young tennis players and of primary and secondary schools pupils (boys and girls) divided into three age groups (12- to 13-year-olds, 14- to 15-year-olds, and 16- to 17-year-olds). Fitness tests items (backwards obstacle course, forward bend on the bench, 20-second hand-tapping, 60-second sit-ups) and three anthropometric measurements (body height, body weight, BMI) were included in this study. The analysis of trends for different periods of measurement in male and female tennis players revealed an increase in some test items and a decrease in others. In the majority of observed fitness test items, young tennis players performed better than their school peers, indicating the positive effects of training and an appropriate selection process of tennis players. Male and female tennis players were taller than the school pupils, and body height values in both groups increased from 1992 to 2008. The body weight and BMI values for male and female tennis players, and male and female pupils in all three age groups have been constantly increasing.

Key words: *tennis, monitoring, motor tests, anthropometric measurements, trends*

Introduction

On an international level, the majority of sports are highly competitive; tennis is no exception. To a great extent, internationally comparable results are related to the level of potential motor and functional abilities and the morphological characteristics of children and youth. Due to changes in lifestyle, several changes have also occurred in the physical fitness of youth, specifically the health indicators that indirectly influence the training process of young sportspeople.

As a result of negative trends in the physical and motor development of children and youth, the monitoring of development has become indispensable throughout the developed world, enabling the collection of data and providing up-to-date information that can be used as an efficient approach to problem solving in the abovementioned issues[1].

Numerous studies have been carried out regarding the morphological characteristics and physical fitness of young people.

Body

Several studies[2–11] have found that children and youth are now considerably taller, heavier, had a higher BMI and had an increase in the prevalence of excess weight than previously.

Fitness

The level of physical fitness, which Rowlands et al. divided into neuromotor and aerobic fitness, frequently changed in previous decades[12]. Most of the changes are negative: Dollman et al. and Tomkinson and Olds found lower aerobic fitness, Westerstahl et al. 2003[4] lower flexibility and muscle endurance[3,13]. Lower neuromuscular power was found also by Moliner-Urdiales et al.[14], while in Brettschneider and Naul[15], speed and flexibility remained almost unchanged. They also found an increase in the neuromuscular strength of abdominal muscles in

Received for publication June 4, 2013

boys and girls. Strel et al. revealed positive changes in the speed of alternate movements, co-ordination of the whole body movement and flexibility[6,9,10]. Negative changes were reported in the neuromuscular endurance of the arms, the explosive power of the legs and aerobic endurance. Runhaar et al. and Matton et al. found decreases in almost all neuromotor fitness variables[7,8].

Activity

In a widespread European study, Brettschneider and Naul found that about two thirds of young Europeans are insufficiently physically active[15]. The level of activity declines with age and is more pronounced in girls. The same was found by Rowlands et al. and Kim et al., who also reported a positive relationship between activity and fitness, and negative relationship between body weight, body fat and activity[12,16].

Within the framework of the project Tennis Measurement System at the Institute of Sport at Faculty of Sport, University of Ljubljana, the physical and motor development of young male and female tennis players has been monitored since 1992. The analysis of the annual tests (23 anthropometric measurements and 22 fitness test items of speed, agility, co-ordination, balance, flexibility, neuromuscular strength and power, aerobic endurance) of selected male and female tennis players members of national junior teams and the correlation with their success in playing tennis has already been presented in several studies[17–21]. The present study only includes fitness tests items and anthropometric measurements from the Sports Education Chart[22] and the Tennis Measurement System[17].

The aims of the study were: 1) to find a trend of changes for selected anthropometric characteristics and motor abilities of young male and female tennis players and primary and secondary schools pupils of three different age groups in the periods between 1992, 2000 and 2008; 2) to find differences in selected variables in young tennis players and to compare them with the results of male and female pupils of the same age.

Materials and Methods

Sample of Subjects

The sample of subjects represented two groups: a sample of young tennis players and a large sample of primary and secondary schools pupils. The sample of the tennis group consisted of all male and female tennis players divided into three age groups (12- to 13-year-olds, 14- to 15-year-olds, and 16- to 17-year-olds). The selection of tennis players was the domain of two national coaches (one for girls and one for boys), who chose a group of subjects each year on the basis of achieved results (national and international ranking list, tennis performance, etc.). The sample of school pupils consisted of all young people participating in the Sports Education Chart project[22], i.e. around 80% of all pupils in Slovenian school population in the observed periods (1992–94, 1999–2001, 2006–08). The number of subject varies in period, test, age category and gender.

Sample of variables

The sample of variables included seven variables, which are shared by the Sports Education Chart and the Tennis Measurement System. The measurements of the school population were carried out at primary and secondary schools during sport education classes. The main data-collecting was performed every year by the specifically trained measurement groups. The results of the tennis players were derived from annual measurements of anthropometrical and physical fitness test items of national team members organised by National Tennis Association in the period between 1992 and 2008. The three physical characteristic test items and four physical fitness tests were the same in the period from 1992 to 2008 (Table 1).

Measurements

Body characteristics

Height was measured to the nearest 0.1 cm without shoes. Subjects were weighed in light clothing without

TABLE 1
THREE PHYSICAL CHARACTERISTIC TEST ITEMS AND FOUR PHYSICAL FITNESS TESTS WERE THE SAME IN THE PERIOD FROM 1992 TO 2008

Test items	Code	Measured capacity	Measuring unit
Body height	Height	Longitudinal dimension of the body	cm
Body weight	Weight	Volume of the body	kg
Body mass index	BMI	Percentage of body mass	kg/m²
Backwards obstacle course	Polygon	Co-ordination of the whole body movement	seconds
Forward bend on the bench	FwdBend	Flexibility	cm
20-second hand-tapping	Tapping	Speed of alternate movement	no. of repetitions
60-second sit-ups	SitUps	Neuromuscular endurance of the torso	no. of repetitions

shoes to the nearest 0.1 kg. The equipment for measuring height and weight were supplied by the Faculty of Sport and was different in different years. The BMI was calculated as the individual's body mass divided by the square of their height (kg × m²).

Physical fitness

The physical fitness tests used were chosen to evaluate co-ordination of whole body movement, flexibility, speed of alternate movement and neuromuscular endurance of the torso. The tests have been used and proved in several studies[17–21,23].

Backwards obstacle course

Co-ordination of whole body movement was measured from the position in which the subject stands on all four limbs with his/her back turned against the obstacles. At the signal of the person performing the measurement, the subject moves backwards, remaining on all four limbs, over in through the obstacle as fast as possible.

Forward bend on the bench

The subject stands bare-footed on a bench, the legs are stretched, and the feet are together and parallel. With hands in front of the body, he/she pushes the board, which slides down the tape measure; the subject maintains this position for 2 seconds.

20-second hand-tapping

The subject has to tap two plates alternately on the tapping board with his/her dominant hand for 20 seconds, while keeping the other hand in between the two plates.

60-second sit-ups

The subject lies on his/her with legs bent and the soles of the feet resting on the ground, hands behind the head and fingers interlocked. When signalled, the subject sits up, twisting his/her trunk and touching one elbow to the opposite knee, then lies back flat again. The sit-up is repeated, the other elbow touching the other knee. The test is continued without interruption as many times as possible for a period of 60 seconds or as long as the subject can continue.

Statistics

Means and standard deviations were calculated for all groups. Differences between means of groups were tested with a multivariate ANOVA (MANOVA) Wilks' lambda test, followed by a univariate ANOVA for each variable. PASW Statistics 18.0 was used for analysis.

Results

Male tennis players

Body height and body weight (Table 2) have been decreasing in male tennis players aged 12 to 13 years and 14 to 15 years, and increasing in a group of 16- to 17-year-old male pupils. In the 16- to 17-year age group, body height increased in the period between 1992 and 2008. In 12- to 13-year-old and 14- to 15-year-old male tennis players, average body weight decreased between 1992 and 2008. An increase in body weight has been observed in the 16- to 17-year-old male tennis players. BMI has been decreasing in 12- to 13-year-old tennis players, whereas in 14- to 15-year-old and 16- to 17-year-old players the values revealed a decrease in the period between 1999 and 2001 and an increase in the period from 2006 to 2008.

In the backwards obstacle course test, young male tennis players achieved significantly lower results in all age groups with the exception of 16- to 17-year-old male pupils. The average values of the whole body co-ordination test item have decreased in 14- to 15-year-old male tennis players. In flexibility, 14- to 15-year-old and 16- to 17-year-old male tennis players achieved lower results; in particular, older pupils revealed a significant negative trend. In the 12- to 13-year-old age group, the trend is combined, as the players in the 1999 to 2001 period achieved better results than their peers in the other two periods. The speed of alternate movements revealed a decrease in 12- to 13-year-old and 14- to 15-year-old male tennis players and a significant increase in the 16- to 17-year-old group. The sitUps test item showed a negative trend of average values in the studied period between 1991 and 2008 for the 12- to 13-year-old group, a combined trend in 14- to 15-year-old and a positive one in 16- to 17-year-old male tennis players.

Male pupils (school population)

In the school population, male pupils of all ages showed (Table 2) an increase of body height and BMI from one studied period to another. Average body height and body weight values for both genders revealed an increase in the studied period between 1992 and 2008 by 2.5% to 7.5%.

In co-ordination of whole body movement, a negative trend of average values has been observed in male and female pupils in the period between 1992 and 2008. Furthermore, in the 16- to 17-year-old category of male pupils, among whom the trend was combined, the results showed a decrease in the 2006 to 2008 period. Decreases ranged from 1% in the 16- to 17-year-old male pupils to 6.4% in 12- to 13-year-old group. Male pupils of all age groups showed lower flexibility through the observed periods (fwdBend); the results were lower by between 4.3% and 5.9%, respectively. In the 1992–2008 period, the average results of speed of alternate movement decreased between 0.6% and 2.5%, respectively. Average values in the test item of neuromuscular endurance of the torso revealed a positive trend in all age groups, with an increase of between 6.6% and 9.6% for male pupils and 8.0% to 14.6% for female pupils.

TABLE 2
MEANS, STANDARD DEVIATION (SD) AND NUMBER OF CASES IN SAMPLES OF MALE TENNIS PLAYERS & SCHOOLBOYS

			Age								
			12- to 13-year-old			14- to 15-year-old			16- to 17-year-old		
			Period			Period			Period		
			1992–94	1999–2001	2006–08	1992–94	1999–2001	2006–08	1992–94	1999–2001	2006–08
Male tennis players	Height	$\overline{X}$	169.0	160.9	159.9	176.2	175.7	173.3	178.1	181.1	182.1
		SD	7.91	8.45	7.60	6.66	6.53	7.05	4.97	5.04	5.28
		N	14	49	59	32	23	41	33	26	10
	Weight	$\overline{X}$	58.2	50.2	48.0	64.0	62.5	62.5	69.2	70.3	72.0
		SD	7.75	9.87	8.72	7.25	8.05	9.08	6.30	4.84	9.87
		N	14	49	59	32	23	41	33	26	10
	BMI	$\overline{X}$	20.29	19.25	18.65	20.59	20.18	20.74	21.85	21.43	21.65
		SD	1.722	2.448	2.008	1.639	1.839	2.029	2.412	1.136	2.230
		N	14	49	59	32	23	41	33	26	10
	Polygon	$\overline{X}$	8.98	10.83	10.97	9.12	9.94	9.49	8.12	9.02	7.92
		SD	3.63	2.11	2.08	1.53	1.52	1.54	1.14	1.56	0.95
		N	14	49	59	20	21	40	10	25	10
	fwdBend	$\overline{X}$	48.4	50.1	43.6	50.1	50.1	47.6	52.0	50.9	49.5
		SD	5.23	5.58	6.48	6.76	5.58	7.47	6.40	7.63	7.23
		N	14	50	59	32	23	41	33	26	10
	Tapping	$\overline{X}$	43.9	43.5	42.7	48.8	48.7	47.7	46.8	50.5	54.6
		SD	4.08	4.95	3.91	4.49	4.71	3.79	6.52	3.54	6.00
		N	14	50	59	21	23	40	12	27	10
	sitUps	$\overline{X}$	55.6	53.4	52.9	57.4	62.8	57.6	60.0	61.2	64.3
		SD	5.18	8.87	7.69	8.55	10.94	9.32	5.37	9.24	7.35
		N	14	50	59	32	23	40	33	26	10
School population – boys	Height	$\overline{X}$	158.1	159.1	160.2	171.3	171.9	172.5	177.4	177.9	178.4
		SD	9.04	9.05	9.20	8.29	8.16	8.17	6.61	6.63	6.82
		N	73224	61273	49777	66966	53662	34273	53961	40968	31775
	Weight	$\overline{X}$	48.7	50.4	52.7	60.8	62.2	64.2	68.9	70.0	71.9
		SD	10.77	11.70	12.82	11.17	11.94	12.82	10.00	10.80	11.58
		N	73224	61273	49777	66966	53662	34273	53961	40968	31775
	BMI	$\overline{X}$	19.31	19.74	20.35	20.62	20.93	21.47	21.84	22.08	22.57
		SD	3.026	3.374	3.780	2.853	3.182	3.513	2.696	2.986	3.208
		N	73224	61273	49777	66966	53662	34273	53961	40968	31775
	Polygon	$\overline{X}$	11.79	12.00	12.60	10.28	10.35	10.78	9.45	9.31	9.55
		SD	3.12	3.37	3.82	2.51	2.69	3.04	2.02	2.03	2.31
		N	73224	61273	49389	66966	53662	34024	53961	40968	31176
	FwdBend	$\overline{X}$	43.7	43.6	41.9	46.6	46.1	44.0	48.5	48.2	46.2
		SD	7.15	7.30	7.61	7.76	7.83	8.30	7.57	7.77	8.17
		N	73224	61273	49542	66966	53662	34136	53961	40968	31439
	Tapping	$\overline{X}$	40.4	39.6	39.5	45.4	44.7	44.3	48.0	48.1	47.7
		SD	5.60	5.35	5.39	6.05	5.86	5.91	5.94	5.88	5.84
		N	73224	61273	49619	66966	53662	34185	53961	40968	31552
	sitUps	$\overline{X}$	42.3	44.5	45.3	46.1	49.3	49.9	47.2	51.6	52.2
		SD	9.16	9.67	10.17	9.34	10.17	10.60	8.95	10.30	10.51
		N	73224	61273	49452	66966	53662	34082	53961	40968	31369

TABLE 3
MEANS, STANDARD DEVIATION (SD) AND NUMBER OF CASES IN A SAMPLE OF FEMALE TENNIS PLAYERS AND SCHOOLGIRLS

			Age								
			12- to 13-year-old			14- to 15-year-old			16- to 17-year-old		
			Period			Period			Period		
			1992–94	1999–2001	2006–08	1992–94	1999–2001	2006–08	1992–94	1999–2001	2006–08
Female tennis players	Height	$\bar{X}$	163.5	162.2	161.4	168.8	166.8	166.3	167.9	167.4	173.6
		SD	6.38	7.25	6.45	2.57	4.81	6.06	1.59	5.09	5.49
		N	12	57	48	11	30	30	4	16	9
	Weight	$\bar{X}$	51.7	48.9	49.3	59.0	58.3	55.6	57.5	60.8	66.2
		SD	6.23	6.59	7.93	5.33	5.41	8.17	4.94	4.69	8.89
		N	12	57	47	11	30	30	4	16	9
	BMI	$\bar{X}$	19.33	18.51	18.80	20.72	20.98	20.06	20.39	21.69	21.93
		SD	1.902	1.653	2.302	1.814	2.025	2.193	1.470	1.127	2.393
		N	12	57	47	11	30	30	4	16	9
	Polygon	$\bar{X}$	8.56	11.03	11.25	8.88	10.86	10.36	8.90	11.63	10.67
		SD	3.05	2.27	1.80	3.08	1.81	1.58	2.88	3.25	2.48
		N	12	56	48	11	28	29	4	16	9
	fwdBend	$\bar{X}$	52.5	51.5	51.0	54.2	54.9	53.7	53.3	56.9	52.8
		SD	5.70	5.45	5.22	4.19	6.18	4.21	5.19	4.67	5.80
		N	12	55	48	11	29	30	4	16	9
	Tapping	$\bar{X}$	46.8	43.4	43.6	47.8	46.4	48.6	46.3	48.7	51.2
		SD	3.31	4.02	3.48	3.54	2.82	4.44	7.23	2.89	2.99
		N	12	56	48	11	29	29	4	14	9
	sitUps	$\bar{X}$	53.4	49.9	48.5	60.7	52.8	53.2	53.3	55.9	58.9
		SD	10.58	7.45	8.05	9.17	7.61	7.70	7.63	6.17	8.57
		N	12	55	48	11	29	30	4	16	9
School population – girls	Height	$\bar{X}$	158.5	159.1	159.6	164.2	164.4	164.6	165.7	165.8	166.1
		SD	7.20	7.10	7.09	5.95	6.00	6.12	5.82	5.93	6.10
		N	69045	57678	46539	63844	49730	30910	56053	38239	30947
	Weight	$\bar{X}$	49.3	50.2	51.6	56.0	56.2	57.5	58.4	58.5	59.9
		SD	9.57	10.25	10.96	8.56	9.29	9.97	8.08	8.74	9.32
		N	69045	57678	46539	63844	49730	30910	56053	38239	30947
	BMI	$\bar{X}$	19.52	19.75	20.16	20.75	20.77	21.18	21.25	21.28	21.70
		SD	3.021	3.311	3.566	2.826	3.091	3.300	2.669	2.896	3.012
		N	69045	57678	46539	63844	49730	30910	56053	38239	30947
	Polygon	$\bar{X}$	13.03	13.01	13.41	12.27	12.06	12.37	12.08	11.57	11.86
		SD	3.19	3.26	3.59	2.84	2.83	3.12	2.61	2.55	2.72
		N	69045	57678	46078	63844	49730	30660	56053	38239	30190
	fwdBend	$\bar{X}$	49.9	49.5	48.3	52.3	52.1	50.3	53.4	53.4	51.3
		SD	6.59	6.83	7.32	6.46	6.71	7.30	6.26	6.62	7.26
		N	69045	57678	46336	63844	49730	30809	56053	38239	30606
	Tapping	$\bar{X}$	40.4	39.8	39.9	43.5	43.4	43.4	44.7	45.3	45.2
		SD	5.25	5.00	5.11	5.41	5.14	5.35	5.46	5.17	5.12
		N	69045	57678	46383	63844	49730	30827	56053	38239	30714
	sitUps	$\bar{X}$	40.0	42.4	43.5	41.2	45.4	46.4	41.4	47.3	48.5
		SD	8.30	8.80	9.42	8.71	9.53	10.03	8.69	9.70	10.11
		N	69045	57678	46218	63844	49730	30713	56053	38239	30415

Female tennis players

An analysis of trends in female tennis players (Table 3) revealed a decrease in body height for 12- to 13-year-olds and 14- to 15-year-olds, whereas in 16- to 17-year-old players the trend of average values was combined. In the 16- to 17-years age group, body height increased by 5.7 cm between 1992 and 2008. The changes of values are even more diverse in body weight, as a combined trend has been revealed in 12- to 13-year-old female tennis players, in 14- to 15-year-olds body weight decreased, and the average body weight in the oldest age group increased by 13.1% in the 1992 to 2008 period. The BMI values in 12- to 13-year-old female tennis players in the period between 1999 and 2001 decreased, increased between 2006 and 2008, whereas in the group of 14- to 15-year-olds, the values increased in the second period and decreased in the last period. In the oldest group of female tennis players, the BMI values have been increasing from one period to another.

In the Backwards obstacle course, the group of 12- to 13-year-old female tennis players were slower in every period and in the groups of 14- to 15-year-old and 16- to 17-year-old players the trend was combined: in the first (1992–94) and second (1999–2001) periods, the results were lower and in the third slightly better. The biggest decline has been observed in 12- to 13-year-old female tennis players, as the results decreased by 23% between 1990 and 2008. The decrease is smaller in 14- to 15-year-old (14.2%) and 16- to 17-year-old (16.5%) female tennis players. A combined trend has also been observed in flexibility in among of 14- to 15-year-old and 16- to 17-year-old female pupils, whereas a group of 12- to 13-year-old female tennis players was less flexible in every period. Female tennis players measured in the 2006–2008 period were less flexible, by 0.9% to 2.9%, compared to their peers in the 1992–1994 period. Among female tennis players, the ability to execute alternate movements decreased by 7.3% in the 12- to 13-year-old age group and increased in 14- to 15-year-old and 16- to 17-year-old groups of female tennis players by 1.6% and 9.6%, respectively. Regarding the neuromuscular endurance of the torso, lower results in the observed period in 12- to 13-year-old (–10.1%) and 14- to 15-year-old (–14.1%) female tennis players were recorded, whereas in the 16- to 17-year-old age group of female pupils they increased by 9.5% (Table 2).

Female pupils

The results of pupils of the same age showed (Table 3) that female pupils were becoming taller, heavier and had higher BMI as well having better neuromuscular endurance of the torso. In co-ordination of the whole body movement, the trend is combined in all three age groups with a negative trend of average values in all age groups in the period between 1992 and 2008. The group of 12- to 13-year-old female pupils revealed lower results by 2.8%, the group of 14- to 15-year-old female pupils by only 0.8%, whereas the oldest age group increased average values by 1.8%. Female pupils in all age groups showed lesser flexibility from one period to another. The negative trend of results was different in individual categories and ranged between 3.3% and 4.1%. In the period between 1992 and 2008, the results in speed of alternate movements decreased in all age groups with the exception of 16- to 17-year-old female pupils, among whom an increase of 1.1% was revealed. In other observed age groups, a decrease of average values in hand tapping ranged between 0.2 % and 1.2%. Average values in the neuromuscular endurance of the torso in female pupils increased by 8% to 14.6%.

Changes in the three observed periods and differences between male and female tennis players, and male and female are presented in Figure 1 for morphological measures and Figure 2 for motor abilities.

Differences in main factors (group, age, gander, period)

Multivariate variance analysis (Table 4) revealed the statistically significant effects of all main factors (group, age, gender and period), as well as in interactions group*period, group*gender and age*gender. The results of the univariate analysis of variance showed the expected differences between the school pupils and tennis players. Differences between the school population and the group of tennis players were statistically significant in all variables except for body weight.

A comparison of all three age groups (12- to 13-year-olds, 14- to 15-year-olds, and 16- to 17-year-olds) revealed statistically significant differences in all observed variables. A comparison of genders also reveals differences in all dependent variables, except in BMI. Differences between different periods of measurement were statistically significant only in the variables of polygon, fwdBend and sitUps. Statistical differences in a larger number of variables were revealed in the interactions of group*period (polygon, sitUps), age*period (body height, tapping, sitUps) and age*gender (body height, body weight, polygon, tapping).

Discussion and Conclusions

In this study, the physical characteristics and the fitness levels of young tennis players were compared across three age categories in three different periods.

Physical characteristics

A decrease in average body height in group 12- to 13-year-old and 14- to 15-year-old tennis players is unexpected, particularly when considering the highly positive trend in the school population. Two reasons can be found for the decrease in body height. Firstly, tennis was extremely popular in the 1980s; consequently, a large number of extremely talented children with above average

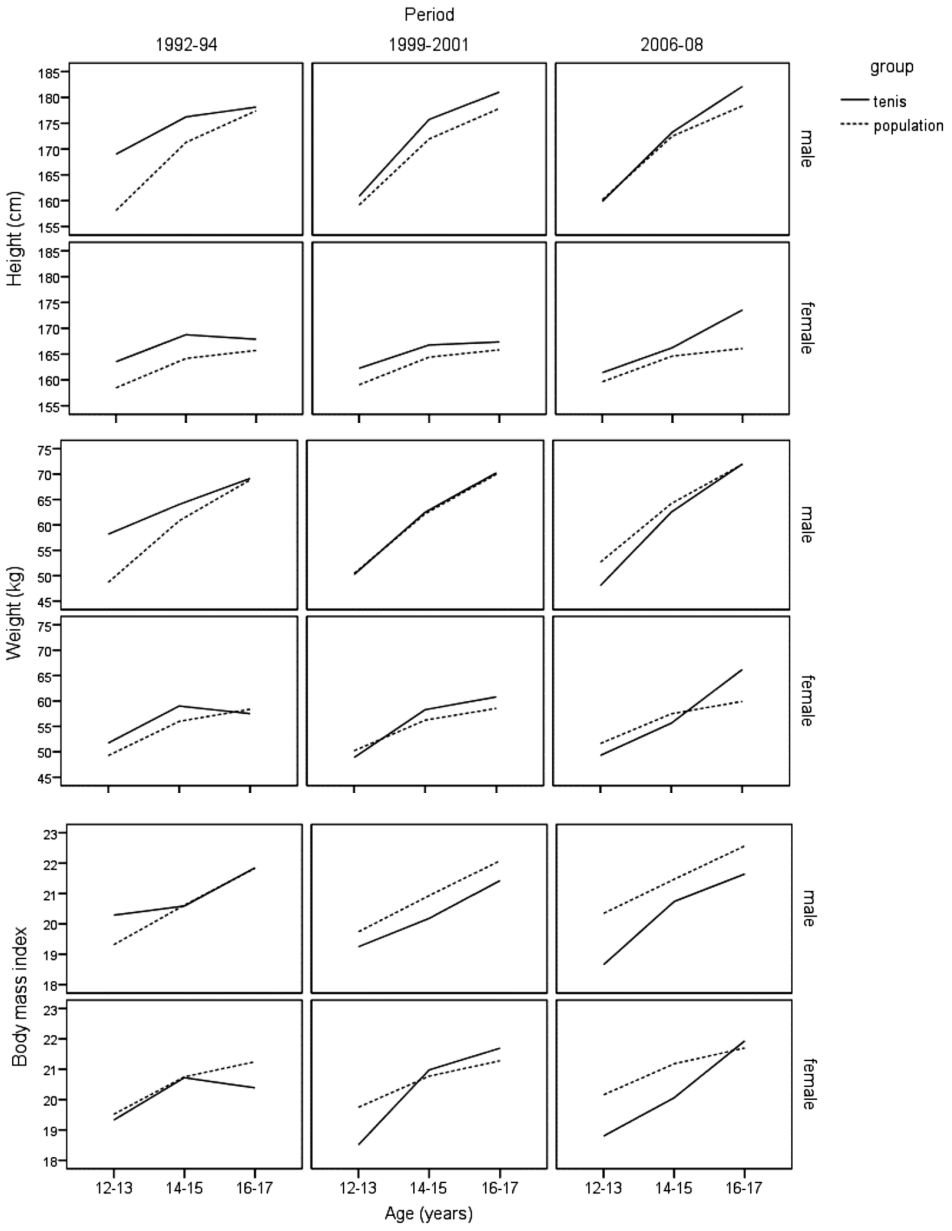

Fig.1. Comparison of morphological measures (Means) between male and female tennis players, schoolboys and schoolgirls in three periods.

anthropometric characteristics participated in tennis. Secondly, the characteristics of tennis game have changed since 1990; the game has become more dynamic and faster, including in younger age groups (12&under, 14&under). In such circumstances, an accentuated body height at that age is more of a hindrance than an advantage. In younger age categories, a player's serve does not have a high impact on success: speed and agility are more beneficial. Thus and Müller found high importance of speed in tennis players of both genders between the ages of 10 and 13 years; similar findings have been presented by Unierzyski and Filipčič & Filipčič for male and female tennis players aged 12 to 14 years, where competitive success has been explained with the statistical significance of speed and agility[21–25]. Certainly, the importance of selection by national coaches cannot be neglected; members of national teams have been selected mostly on a basis of actual tennis performance and position on the ranking list.

In older age categories, body height is more emphasised and has a positive correlation with the efficiency of serve[26]. Body height also has (together with more prominent extremities) a positive influence on the efficiency of the utilisation of the kinetic chain in the execution of tennis strokes; it also increases leverage, which is essential in rotational movements of hips and shoulders, i.e. angular momentum[27]. Coordinated rotational movements of body segments and the tennis racket increases the speed of the racket and the ball, amounting to 30 m/s in groundstrokes and in serves up to 45 m/s[28,29].

In male and female 12- to 13-year-old and 14- to 15-year-old tennis players, average body weight has decreased in the observed period, whereas in 16- to 17-year-old male and female tennis players it has increased. Lower body weight in younger age categories enables quick initiation of movements (split step and speed of accelera

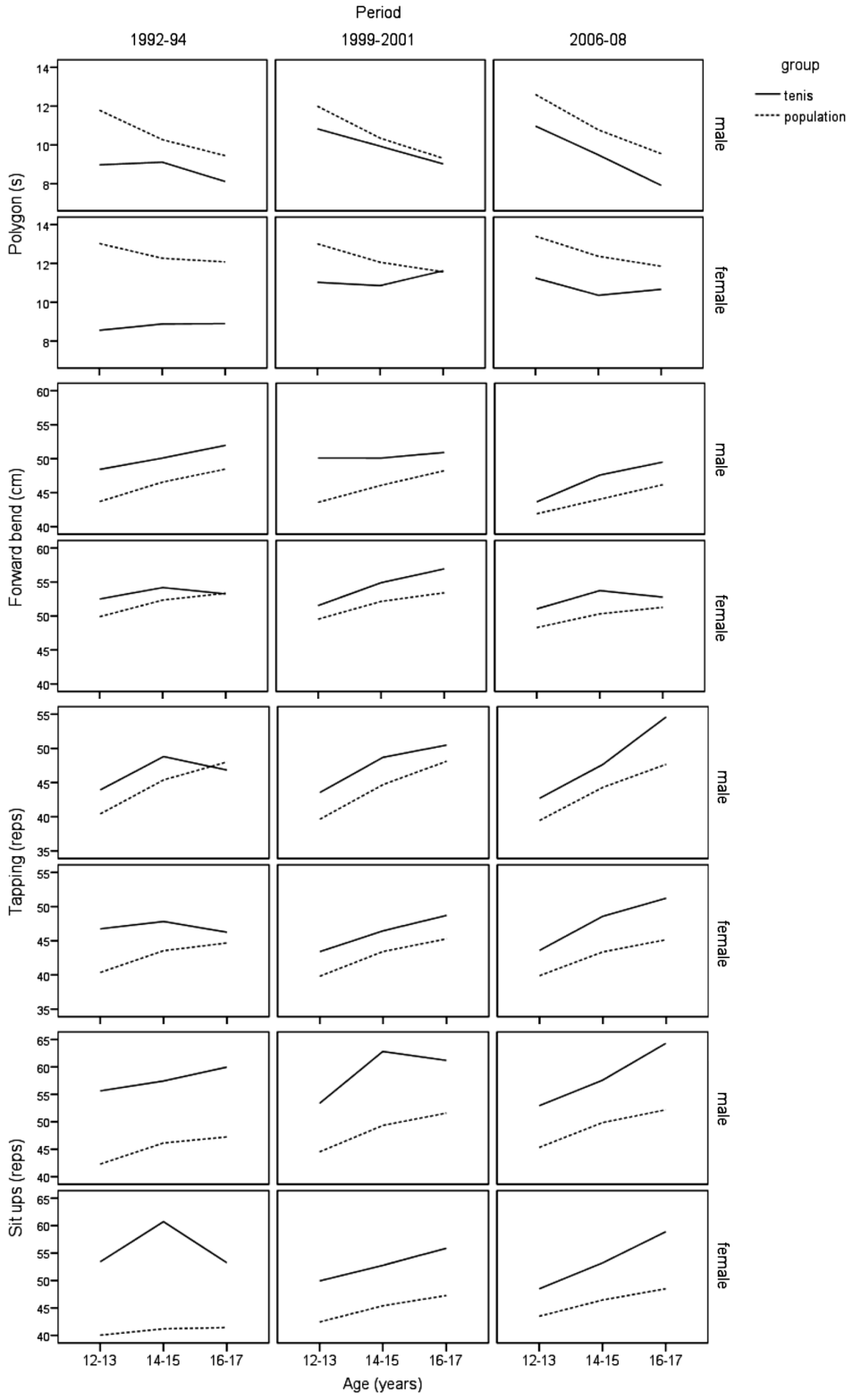

Fig. 2. Comparison of motor abilities (Means) between male and female tennis players, schoolboys and schoolgirls in three periods.

TABLE 4
UNIVARIATE AND MULTIVARIATE (MANOVA) F-TESTS FOR DIFFERENCES OF GROUP MEANS (F VALUES, SIGNIFICANT AT 0.05 LEVEL, ARE UNDERLINED)

Source	Height	Weight	BMI	Polygon	Fwdbend	Tapping	Situps	MANOVA
Group	59.5	2.4	6.4	96.5	51.3	126.9	361.9	68.2
Age	332.4	206.4	50.0	24.6	26.5	134.6	46.1	73.4
Gender	232.2	86.6	2.1	53.4	144.5	7.9	52.2	91.6
Period	0.8	1.5	0.8	7.5	14.5	1.2	3.4	5.9
Group * age	0.4	0.1	0.4	4.1	0.4	0.5	1.4	1.6
Group * period	2.2	2.5	1.9	9.1	0.6	2.8	7.3	4.7
Group * gender	0.0	0.1	0.0	6.0	3.1	1.7	0.4	3.9
Age * period	2.7	1.7	0.3	1.5	0.2	4.0	2.5	1.4
Age * gender	61.6	17.1	0.6	7.0	0.6	7.6	1.6	11.6
Period * gender	0.8	0.2	0.3	0.5	0.9	0.5	0.9	0.9
Group * age * period	3.6	2.3	0.7	0.6	0.5	2.9	1.1	1.2
Group * age * gender	0.3	1.1	0.7	0.4	0.1	0.1	0.3	0.3
Group * period * gender	1.8	1.5	0.8	1.6	0.5	0.9	1.8	1.2
Age * period * gender	1.3	0.7	0.9	0.1	1.5	0.7	1.6	1.2
Group * age * period * gender	1.3	0.7	0.9	0.1	1.2	0.6	1.6	1.1

tion), efficient positioning for the shot (footwork and movement patterns) and changes in direction (agility). Thus, Westerstahl et al. (2003)[4] found that the increased body weight of young people results in worse results in movements, where the body has to overcome the gravitational force (run, walk, jumps, sit-ups). Consequently, lighter tennis players have more aerobic endurance as they carry less body weight.

A significant increase of average body weight among 16- to 17-year-old male and female tennis players confirms the findings from other studies[10]. Increased body weight in male tennis players is a result of hormonal changes in puberty and training aimed at increases of neuromuscular strength and power. In male tennis players, from the aspect of significantly increased values, it can be concluded that the possibility of excess body weight exists. According to the findings of numerous studies that revealed the phenomenon of increased numbers of children and youth with excess body weight, the phenomenon of non-optimal weight also occurs in trained female athletes[2–4,30–34].

It was expected that young tennis players would have lower BMI values than their school peers in the majority of age groups and observed periods. Nevertheless, some studies examining the correlation of the anthropometric characteristics and the sports activity of young people showed that there is no clear evidence for a relationship between BMI and physical activity [8,15]. Undoubtedly, there are differences in average BMI values in all three age groups, as the values have been constantly increasing. Strel et al. found that BMI begins to differ with gender, particularly after the age of 16 years[5]. The present study of young tennis players did not find differences in BMI for different periods of measurements, indicating that athletes with regular sports activity regulate their BMI values, which was not the same for the school population. The comparison of the results showed that in 1983 the percentage of school pupils having an appropriate weight was about 10% lower than in 2003. The biggest percentage of overweight Slovenian children, according to the BMI (25–30 $kg \times m^{-2}$) was found in boys aged 9 to 14 years and girls aged 8 to 13 years. Westerstahl et al. investigated changes in 16-year-olds' fitness from 1974 to 1995[4]. Both boys and girls in 1995 weighed more and had a higher BMI than in 1974. Similarly, Troiano et al. found that the largest increase in BMI values occurred in the period between 1976 and 1980[33]. Herman and Groffik interpreted the increase in the BMI values in Polish children and youth to be a result of biological changes and improved living conditions in the society[35].

Physical fitness

The backwards obstacle course test item revealed a decline in both young tennis players as well as in the school population in the majority of age groups, whereas in male and female tennis players (14- to 15-year-old, 16- to 17-year-old) in the 2006 to 2008 period an increase of average values has been observed. This is in line with the conclusions by Strel et al., revealing a strong positive trend in Slovenian children and youth between 1990 and 2000[10]. It was found that the results of this test item depend on the efficiency of sensory motor reception centres, processing and storing of motor information, and from the activity of cortical centres in the central nervous system. Positive changes in coordination have also been observed in boys in Portugal, aged 6 to 9 years, with the ability of coordination increasing both with age and both genders. The boys' test values are higher than those of the girls[15].

A negative trend of average values in flexibility has been observed in both young tennis players and the school pupils. It can be concluded that the passive and sedentary lifestyle of children and youth, both regularly and irregularly active in sport, is also reflected in the progressively worse results in flexibility. In all age categories of the school pupils, the average values of flexibility decreased in the period between 1992 and 2008. Studies on Portuguese children aged 6 to 9 years indicate that girls are more flexible than boys; however, a negative trend has been observed in both genders[15]. In contrast, Strel et al. found opposite results in the period between 1990 and 2000, i.e. an increase in the average values of flexibility by 1% to 3%[9]. It is obvious that the negative effects of inactive spending of free time in children also result in poorer results of flexibility, which only worsen in young people with age.

The study by Kovač et al. found a positive trend of results in the period between 1992 and 2008 in 16- to 17-year-old tennis players[36]. However, the same is not true for other age groups of tennis players and the school pupils, among whom the results have decreased. A positive change of average values in hand tapping in 16- to 17-year-old male and female tennis players is a result of the effects of planned and programmed training, which for tennis requires fast and repetitive execution of movements with the dominant hand. Undoubtedly, one of the more salient characteristics of efficient tennis technique is an optimal kinetic chain, which results in the high speed of the racket towards the ball and which, in the last part of the shot, also includes upper- and under-arm movement. The negative trend in the speed of alternate movements in other age groups is not in compliance with the findings by Strel et al., who found positive changes in the period between 1990 and 2000[9]. Among female pupils, the results have increased until the age of 14 years and in boys up to the age of 19 years. The hand tapping test measures the frequency of simple movement. The ability to quickly execute simple movements depends on the speed of transfer of information to motor centres and the co-ordinated regulation of simple motor tasks. Due to the demand for the highest number of repetitions, which follow in opposite directions, the results depend on the ability to quickly change the activation of synergists and antagonists, personal rhythm and a parallel analysis of information or a certain level of working of intellectual potential for perception, analysing and correcting movement.

The neuromuscular endurance of the body in all age groups of male and female pupils as well as in 16- to 17-year-old male and female tennis players significantly improved in the observed period. The increase of results in the neuromuscular endurance of the body was observed by Strel et al., who found that the results in boys between 1990 and 2000 improved by 15%, whereas in girls in the same period the trend of improvement was observed from the age of 14 to 19 years[9]. Kovač et al. defined sit-ups as an activity of large muscle groups performed while overcoming resistance by repeating the flexion in the hip joint[36]. Longer lasting activity requires activation of the mechanism for regulation of the duration of excitation; for successful execution, the assistance of the mechanism for synergy automation and the regulation of tonus, which manages inter-muscular co-ordination and thus influences the economy of movement, is also required. Many researchers found that in recent decades young people achieved better results in their power of legs and the neuromuscular endurance of abdominal musculature[5,10,15,37], but some also observed decreases in the results[4,38]. The conclusions of such studies indicate that a positive trend of changes in the average values of neuromuscular endurance of the body has been observed, particularly in older tennis players and the groups of boys and girls. The reasons for positive changes lie in a greater understanding of young people about the importance of activity, care for external looks and wide supply (fitness centres, sport clubs) as well as in media support for various sports programmes (body pump, Pilates etc.) and equipment (exercise ball etc.), intended for the development of neuromuscular strength and power.

Trends of differences in main factors (group, age, gander, period)

A comparison of average values of individual variables among young tennis players and their school counterparts reveals the expected better results of selected and trained athletes in physical fitness tests. Looking at body weight, both male and female pupils had higher values in all three observed periods, compared to male and female tennis players. Additionally, a comparison with the study by Kovač et al. revealed that young tennis players achieved higher values in the variable body height, and male pupils did in body weight[36]. The conclusions confirm the findings that the continual sports activity of young tennis players has a positive influence on the regulation of body weight. As tennis players of both genders are a selected group, subjected to strict selection criteria and long-term training processes, it was to be expected that they would achieve higher average values in body height and all physical fitness test items and lower values in body weight in BMI. Similarly, Philippaerts et al. found that although the differences between young football players and non-athletic adolescents are small, it is possible that the timing of growth in muscle mass is also influenced by systematic soccer-specific training[39].

Differences between the three age groups (12- to 13-year-old 14- to 15-year-old 16- to 17-year-old), genders (male, female), and the interactions of group*gender and age*gender have been examined in numerous studies; they indicated a highly intensive and diverse physical development and changes, which occur between the ages of 11 and 17 years, as well as biological differences between boys and girls, and the differences in the pace of their physical development. Another representative sample of 16-year-old Swedish pupils found that differences in motor ability between boys and girls were influenced by educational programmes status. Boys were statistically significantly better in sit-ups, run-walk, two-hand lift, Sargent jump

and handgrip test item[4]. Brettschneider and Naul found that the patterns of the development of motor abilities in the course of childhood up to the ages of 10 and 12 years are almost identical, regardless of study and country. There are differences concerning age and gender[15].

The period of measurement (period, group*period) has a significant influence on the results in certain groups (1992 to 1994, 1999 to 2001, 2006 to 2008). A decline in the results of fitness tests in the 1974–1995 period was also observed by Westerstahl et al., as the boys and girls declined in tests bench-press, sit-ups, and run-walk; boys had improved results in the Sargent jump and the girls in two-hand lift[4].

In the period between 1990 and 2000, changes in the motor skills of the Slovenian school population were diverse with regard to the observed physical fitness abilities, characteristics and age group. There are distinct and positive changes in strength in boys and girls aged 8 to 19 years; there is a moderate increase in coordination of body movement, strength of abdominal muscles (sit-ups), flexibility (forward bend on the bench) for both genders, in particular for girls, whereas negative trends can be identified in endurance capacity for boys and girls and in neuromuscular strength and endurance of the upper limbs, particularly for boys. No changes have been observed in explosive power and speed[15].

However, Strel et al. warned about a decidedly negative trend in the period from 2000 to 2005 (the strongest since 1970), which could have long-term consequences[6]. A comparison of the average value index of motor abilities (eight motor test items) showed positive changes in girls and negative changes in boys. For girls, positive changes are less noticeable than in the decade from 1990 to 2000, whereas in boys a moderate positive trend has turned into a negative one in previous five years.

All these different studies seem to suggest that over the previous two or three decades strength has increased among older adolescents, but aerobic fitness and neuromuscular endurance have decreased. The trend is obvious: the overall level of physical fitness and motor performance of today's Swedish, Finish, Dutch and Polish children and adolescents is lower than it was 15 to 25 years ago[8,15,40].

While negative changes in the school pupils were to be expected and understandable, the same is not true for the young tennis players. However, even this part of the population has experienced some negative changes due to the same reasons as stated for the school population. Although young tennis players are daily subjected to the training process, they are also subjected to the same negative factors, such as inappropriate diet.

The next important reason for the decline of results lies in the initial selection of tennis players. Analyses of the results of motor test items revealed that the entry level of tennis players of both genders is lower from one period to another. Nowadays, children who decide to play tennis have a lower level of physical fitness than their peers in the period between 1992 and 2000. Other reasons for the declining status of physical fitness are also social and particularly financial factors, which indirectly influence the types of children who will start to play tennis and even more importantly who will remain in tennis. Participation in tennis has become more expensive; furthermore, the financial support of sponsors, tennis clubs and associations has been decreasing.

It has been accepted that the amount of free time that young people use for sport correlates with their motor efficiency[41]. In recent years, significant changes have been observed in the way young people spend their free time[42]. Boys are more active than the girls. Nevertheless, the amount of free-time motor activity gradually decreases with age in both genders[15,41–45]. The results of several studies indicated that motor activity significantly decreases with age: at a rate of 3% annually in boys and 7% in girls[15]. Similarly, the results for Slovenia show that the proportion of secondary-school boys who do not participate in any sports activity rose from 10.6% in 1993 to 15.2% in 2004[9,41]. This is a result of a decline of interest for sport in one's free time and the downward trend of physical education classes in the curriculum. Hardman and Kovač were quite concerned, since it is generally acknowledged that physical activity has several benefits that improve health status and quality of life in adolescents[46,47]. Additionally, children and youth with lower motor competences are less able to participate fully in many sports and recreational activities typically enjoyed by their well-coordinated peers[15,42,48–52].

One of the main reasons for both positive and negative changes is the lifestyle of young people. They tend to be less physically active, they participate in sport less often, they spend their free time inactively, and they have inappropriate diets. The consequences of these factors are higher or even excess body weight and declining levels of physical fitness. In contrast, certain positive changes are influenced by the instruction of young people about the importance of physical activity, care for external looks and a wide supply of as well as media support for various sports programmes and equipment. There is also a significant positive relationship between physical activity and cognitive functioning[53]. Physical activity is influenced by three domains: interpersonal (biological, psychological and behavioural influences), social (family or peer support, modelling), and environmental (facilities, communities, accessibility, etc.). There are significant interactions between these factors[42,54]. Finally, it can be concluded that (as expected) young tennis players were better in the majority of observed variables than their school peers, indicating the positive effects of training and, also to a certain extent, the appropriate selection process of tennis players.

It is the understanding of the authors that the sample of young tennis players was relatively small in certain periods and age groups, which leads to a higher influence of individuals, skewing towards the positive or negative end of the scale. Nevertheless, the sample has been carefully selected as it represents most successful young tennis players, who within their age group have similar volume and contents of training. It is the opinion of authors

that the groups of young tennis players and school population had different starting points in physical fitness and characteristics as well as in the volume and contents of sports activities. Undoubtedly, the study will have to be upgraded in the future with a comparison of results and conclusions of studies for the period between 2001 and 2012, which were not yet available at the time of analysis.

Acknowledgements

The authors wish to express their gratitude to the Slovene Tennis Association and the Institute of Sport at Faculty of Sport, University of Ljubljana, and the Ministry of Education and Sport of the Republic Slovenia, who allowed access to data on young tennis players and school pupils.

REFERENCES

1. STARC G, STREL J, KOVAČ M, Physical and motor development of Slovenian children and youth in figures: 2007/2008 academic year (University of Ljubljana, Ljubljana, 2010). — 2. RASMUSSEN F, JOHANSSON M, HANSEN HO, Acta Pediatrica, 88 (1999) 431. — 3. DOLLMAN J, OLDS T, NORTON K, STUART D, Ped Exerc Sci, 11 (1999) 108. — 4. WESTERSTAHL M, BARNEKOW-BERGKVIST M, HEDBERG G, JANSSON E, Scandinavian Journal of Medicine & Science in Sports, 3 (2003) 128. — 5. STREL J, KOVAČ M, JURAK G, Study on young people's lifestyle and sedentariness and the role of sport in the context of education and as a means of restoring the balance: Case of Slovenia – Long version, accessed 12.05.2013. Available from: URL: http://www.fsp.uni-lj.si/didaktika. — 6. STREL J, KOVAČ M, ROGELJ A, Evaluation of monitoring of motor and physical development of children and youth in the 2001/2002 academic year and comparison of some parameters of sports-education chart with academic year 2001 and the period 1990–2000 (University of Ljubljana, Faculty of sport, Ljubljana, 2006). — 7. MATTON L, DUVIGNEAUD N, WIJNDAELE K, PHILIPPAERTS RM, DUQUET W, BEUNEN G, CLAESSENS AL, THOMIS M, LEFEVRE J, Am J Hum Biol, 19 (2007) 345. — 8. RUNHAAR J, COLLARD DC, SINGH AS, KEMPER HC, MECHELEN VAN W, CHINAPAW M, Journal of Science & Medicine, 13 (2010) 323. — 9. STREL J, KOVAČ M, JURAK G, BEDNARIK J, LESKOŠEK B, STARC G, MAJERIČ M, FILIPČIČ T, Certain morphological, motor, functional and health parameters of Slovenian children and youth in the period 1990–2000 (University of Ljubljana, Ljubljana, 2003a). — 10. STREL J, KOVAČ M, ROGELJ A, LESKOŠEK B, JURAK G, STARC G, MAJERIČ M, KOLENC M, Evaluation of monitoring of motor and physical development of children and youth in the 2001/2002 academic year and comparison of some parameters of sports-education chart with academic year 2001 and the period 1990–2000 (Agency for Sport, Ljubljana, 2003b). — 11. JUREŠA V, MUSIL V, KUJUNDŽIĆ- TILJAK M, Coll Antropol, 36 (2012) 47. — 12. ROWLANDS AV, ESTON RG, INGLEDEW DK, J Appl Physiol, 86 (1998) 428. — 13. TOMKINSON GR, OLDS TS, Med Sport Sci, 50 (2007) 168. — 14. MOLINER-URDIALES D, RUIZ JR, ORTEGA FB, JIMÉNEZ-PAVÓN D, VICENTE-RODRIGUEZ G, REY-LÓPEZ J P, MARTÍNEZ-GÓMEZ D, CASAJÚS JA, MESANA MI, MARCOS A, NORIEGA-BORGE M J, SJÖSTRÖM M, CASTILLO MJ, MORENO L A, J Sci Med Sport, 13 (2010) 584. — 15. BRETTSCHNEIDER WB, NAUL R, Study on young people's lifestyle and sedentariness and the role of sport in the context of education and as a means of restoring the balance. Final report (University of Paderborn, Paderborn, 2004). — 16. KIM J, MUST A, FITZMAURICE GM, GILLMAN MW, CHOMITZ V, KRAMER A, MCGOWAN R, PETERSON KE, The International Journal of Behavioral Nutrition and Physical Activity, 13 (2005) 1246. — 17. FILIPČIČ A, Reliability and validity of chosen motoric tests in tennis. MS Thesis. In Slovene. (University of Ljubljana, Ljubljana, 1993). — 18. FILIPČIČ A, Evaluation of Competitive and Potential Performance of Young Tennis Players. PhD Thesis. In Slovene. (University of Ljubljana, Ljubljana, 1996). — 19. FILIPČIČ A, Correlation of tennis motor skills and basic anthropometric characteristics and its influence on the competition successfulness of young tennis players. In: KONDRIĆ M, FILIPČIČ A (Eds) Scientific approach in table tennis and tennis in Slovenia (Sports Books Publisher, Toronto, 2009a). — 20. FILIPČIČ A, Regression analysis of tennis–specific motor abilities and the competition efficiency of young female tennis players. In: KONDRIĆ M, FILIPČIČ A (Eds) Scientific approach in table tennis and tennis in Slovenia. (Sports Books Publisher, Toronto, 2009b). — 21. FILIPČIČ A, FILIPČIČ T, Acta Gymn, 35 (2005a) 35. — 22. STREL J, Sports Educational Chart (Ministry for Education and Sport, Ljubljana, 1996). — 23. FILIPČIČ A, FILIPČIČ T, Kinesiology, 37(2005b) 164. — 24. MÜLLER E, Leistungssport, 19 (1989) 5. — 25. UNIERZYSKI P, Motor Abilities and Performance Level Among Young Tennis Players In: Proceedings (3rd International Conference »Sport Kinetics '93«, Academy of Physical Education, Poznan, 1994) — 26. VAVERKA F, Grand Slam 2008–2009 (Palacky University Olomouc, Olomouc, 2010). — 27. BAHAMONDE RE, J Sport Sci, 8 (2000) 579. — 28. REID M, ELLIOTT B, Sports Biomech, 1 (2002) 47. — 29. REID M, Loading and velocity generation in the high performance tennis serve. PhD Thesis. In Australian. (University of Western Australia, Perth, 2007). — 30. FREEDMAN DS, SRINIVASAN SR, VALDEZ RA, WILLIAMSON DF, BERENSON GS, Pediatrics, 99 (1997) 420. — 31. LINDGREN GW, HAUSPIE RC, Ann Human Biol, 16 (1989) 397. — 32. RASMUSEEN F, JOHANSSON M, Acta Pediatrica, 89 (2000) 888. — 33. TROIANO RP, FLEGAL KM, KUCZMARSKI RJ, CAMPBELL SM, JOHNSON CL, Arch Pediatr Adolesc Med, 149 (1995) 1085. — 34. WEDDERKOPP N, Atherosclerotic cardiovascular risk factors in Danish children and adolescents. A community based approach with a special reference to physical fitness and obesity (University of Southern Denmark, Kraj, 2001). — 35. HERMAN D, GROFFIK D, Study on young people's Lifestyle and sedentariness and the role of sport in the context of education and as a means of restoring the balance. Case of Poland (Academy of Physical Education, Katowice, 2004). — 36. KOVAČ M, LESKOŠEK B, STREL J, Kinesiology, 39 (2007) 62. — 37. RYCHTECKÝ A, Study on young people's lifestyles and sedentariness and the role of sport in the context of education and as a means of restoring the balance. Czech, Polish, Slovak and Slovenian cases (Charles University of Prague, Prague, 2004). — 38. CRAIG C, BEAULIEU A, CAMERON C, Data analysis of fitness and performance capacity. Results from the 1991 Canada Fitness Survey and the 1988 Cambell Survey on Well-being in Canada (Canadian Fitness and Lifestyle Research Institute, Ottawa, 1994). — 39. PHILIPPAERTS RM, VAEYENS R, JANSSENS M, RENNTERGHEM VAN B, MATTHYS D, CRAEN R, BOURGOIS J, VRIJENS J, BEUNEN G, MALINA RM, Journal of Sports Science, 24 (2006) 221. — 40. BRONIKOWSKI M, KROL-ZIELINSKA M, Changes in level of motor fitness in 13 and 14 years old pupils from Poland (Akademia Wychowania Fizycznego, Poznan, 2001). — 41. JURAK G, KOVAČ M, STREL J, MAJERIČ M, STARC G, FILIPČIČ T, BEDNARIK J, KOLENC M, Sports activities of Slovenian children and young people during their summer holidays (University of Ljubljana, Ljubljana, 2003). — 42. JURAK G, Anthropological Notebooks, 12 (2006) 79. — 43. CURRIE C, ROBERTS C, MORGAN A, SMITH R, SETTERTOBULTE W, SAMDAL O, Young people's health in context. Health behaviour in school-aged children (HBSC) study: International report from the 2001/2002 survey (World Health Organization, Regional Office for Europe, Copenhagen, 2004). — 44. RIDDOCH CJ, ANDERSEN LB, WEDDERKOPP N, HARRO M, KLASSON-HEGGEBO L, SARDINHA LB, Medicine and Science in Sports and Exercise, 36 (2004) 86. — 45. WOODFIELD L, DUNCAN M, AL-NAKEEB Y, NEVILL A, JENKINS C, Pediatrics Exercise Science, 14 (2002) 277. — 46. HARDMAN K, European physical education/sport survey. Report on summary of findings (Council of Europe, Strasbourg, 2002). — 47. KOVAČ M, Anthropological Notebooks, 12 (2006) 97. — 48. HANDS B, Journal of Science and Medicine in Sport, 11 (2008) 155. — 49. KOVAČ M, The development of education. National report of the Republic of Slovenia by Ministry of Education, Science and Sport in Physical education (Ministry of Education, Science and Sport, Ljubljana, 2001). — 50. MACKELVIE KJ, KHAN KM, MCKAY HA, British Journal of Sports Medicine, 36 (2002) 250. — 51. SOTHERN MS, LOFTIN M, SUSKIND RM, UDALL JN, BLECKER U, European Journal of Pediatrics, 158 (1999) 271. — 52. TELAMA R, NUPPONEN H, PIERON M, European Physical Education Review, 11 (2005) 115. — 53. SIBLEY BA, ETNIER JL, Pediatric Exercise Science, 15 (2003) 243. — 54. SALLIS JF, OWEN N, Physical activity and behavioral medicine (Sage, Thousand Oaks, 1999).

T. Filipčić

University of Ljubljana, Faculty of Education, Kardeljeva ploščad 16, 1000 Ljubljana, Slovenia
e-mail: tjasa.filipcic@pef.uni-lj.si

RAZLIKE U FIZIČKOJ SPREMI MEĐU MLADIM TENISAČIMA OD 1992. DO 2008. GODINE

S A Ž E T A K

Cilj ovog istraživanja bio je pronaći trend promjena odabranih antropometrijskih karakteristika i motoričkih sposobnosti mladih muških i ženskih tenisača iz tri različite dobne skupine. Trendovi su promatrani u razdoblju između 1992., 2000. i 2008. Osim toga, uključena je i usporedba rezultata tenisača i učenika. Uzorak ispitanika su mladi tenisači i učenici osnovnih i srednjih škola (dječaci i djevojčice) podijeljeni u tri dobne skupine (12 do 13-godišnjake, 14- do 15-godišnjake, te 16- do 17-godišnjake). U studiju su uključeni testovi fizičke spreme (poligon s preprekama unatrag, trbušnjaci na klupi, 60 sekundi trbušnjaka) i tri antropometrijska mjerenja (tjelesna visina, tjelesna težina, BMI). Analiza trendova za različita razdoblja mjerenja kod muških i ženskih tenisača otkrila je povećanje nekih ispitnih predmeta i smanjenje drugih. U većini promatranih testova fizičke spreme avke, mladi tenisači imaju bolje rezultate od svojih školskih kolega, što ukazuje na pozitivne učinke treninga i odgovarajući postupak odabira tenisača. Muški i ženski tenisači bili su viši od učenika u školi, i tjelesne visine. U obje skupine su se od 1992. do 2008. povećale tjelesne težine i BMI vrijednosti za muške i ženske tenisače, muške i ženske učenike u sve tri dobne skupine te se stalno se povećava.