Biology of Sport, Vol. 21 N°2, 2004

DEVELOPMENT OF THE AEROBIC FITNESS IN ELITE YOUNG ORIENTEERS

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Abstract. The aim of the study was to estimate the age-dependent changes in the indices of the aerobic fitness of young male and female elite orienteers aged 16 to 26 and 15 to 29 years, respectively. Two methods of the analysis of the results were employed. In the first method, the results were obtained from the subjects examined three to seven times at one-year intervals. The changes in the values of the studied indices were calculated for each pair of the consecutive years. The results were analysed in six age groups each of which consisted of eight to 13 female and ten to 18 male. Mean values of the individual annual changes in the indices were calculated depending on the age of the examined subjects. In the second method, the orienteers were divided into four age groups each consisting of ten males and six females who, during the period from 1990 to 2000, exhibited the highest maximal oxygen uptake; in this case, the differences between the means obtained for each group were analysed. The test exercise consisted of running until exhaustion on a mechanical treadmill with the workload being increased by 2 km per hour every five minutes. During the exercise, the following indices were recorded: speed of the run (V), heart rate (HR), pulmonary ventilation (VE), oxygen uptake (VO_2), and lactate concentration (LA) in the arterialised blood. Both the maximal (max) and at the lactate threshold (OBLA) values of the examined indices were estimated. In addition, the economy of running (RE) was calculated. It was found that the subjects' body mass increased or tended to increase until the age of 23 years. The 16-17-year-old males demonstrated elevation of the absolute values of VO_2max, and the values of V_{OBLA} increased or tended to increase in the males aged 16-19 years. In the 16-18-year-old boys and the 15-17-year-old girls improving in the RE was detected. No significant alterations in the values of the remaining indices could be demonstrated. The obtained results indicate that in male and female athletes representing such a typical endurance sport as orienteering, elevation of the values of the aerobic fitness indices with increasing age of the subjects is relatively early suppressed

(Biol.Sport 21:105-120, 2004)

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Key words: Orienteering - Aerobic fitness - Young

Introduction

Based on the results of numerous studies conducted in the USA, Canada, and seven European countries, Shvartz and Reibold [17] established that in males maximal oxygen uptake (VO_2max) expressed in $L{\cdot}min^{-1}$ increases with age until 18-19 years proportionally to the elevation of the body mass, whereas in females the values of this index level off between 15.5 and 20 years of age. The highest values of VO_2max expressed in $mL{\cdot}kg^{-1}{\cdot}min^{-1}$ were recorded in boys aged 12-13 years and in the nine-year-old girls; later in life, no further increase or even the gradual reduction in the VO_2max values were recorded. In fact, the most pronounced decrease of VO_2max related to the subject's body mass occurs during puberty. Similar results were obtained by Cempla and Szopa [1] for the Polish population. In young professional athletes representing different sports equivocal data have been reported with respect to the age-related changes in the indices of physical fitness. For instance, Ingjer [6] could not detect any increase in VO_2max related to the body mass in cross-country skiers older than 15-16 years. Similar results were reported by Faff *et al.* [4] in tennis players and DeKoning *et al.* [2] in speed skaters. On the other hand, Rusko [15] demonstrated that in the elite cross-country skiers VO_2max increased even after the age of 20 years. To our knowledge, no report has been published so far on changes in the physical fitness of young male and female orienteers who generally exhibit high aerobic capacity. In fact, the maximal oxygen uptake of the leading orienteers exceeds 80 $ml{\cdot}kg^{-1}{\cdot}min^{-1}$ in males and 65-70 $ml{\cdot}kg^{-1}{\cdot}min^{-}1$ in females [7,8,14]. In both male and female orienteers, a statistically significant correlation was found between the VO_2max as well as VO_{2AT} values and the scores in orienteering [7]. As a result, the training in this game, apart from the technical aspects, is focused mainly on the development of running endurance and physical fitness. Notably, the best results in orienteering are usually scored by the athletes who are over 23-25 years old. In view of this, the aim of the present study was to characterize the dynamics of alterations in the selected indices of physical fitness in young male and female orienteers during the period of life in which most of them demonstrate improved scores in orienteering.

Material and Methods

The investigation was carried out from 1990 to 2000 at the end of the pre-competition or at the beginning of the competition period. Two methods of analysis of the results were employed. In the first method, the results were obtained from the subjects examined three to seven times at one-year intervals who trained systematically for at least a year before the onset of the investigation. The changes in the values of the studied indices were calculated for each pair of the consecutive years. The results were analysed in six age groups each of which consisted of eight to 13 female and ten to 18 male orienteers who, at the first examination (out of the consecutive two) were: over 15 and under 16 years old (group 1, females only), over 16 and under 17 years old (group 2), over 17 and under 18 years old (group 3), over 18 and under 19 years old (group 4), over 19 and under 23 years old (group 5), and over 23 years old (group 6). Overall, in this run of the study 42 orienteers (25 males and 17 females) were examined. In the second part of the investigation, the athletes were divided into four age groups composed of 16-18, 18.1-19, 19.1-24, and over 24 years (24-29 females and 24-26 males) old male and female athletes. Each group was allotted ten males and six females demonstrating the highest maximal oxygen uptake relative to the body mass. If a subject was examined several times in the same age group, only the results with the highest values of VO_2max were used for the analysis. The results obtained by the athletes of various ages who scored best in the consecutive age compartments were analysed accordingly in several age groups. Overall, in this run the results obtained in 24 male and 11 female orienteers were used. The subjects were informed about the programme of the study and expressed their informed consent to participate. In case of the minors, the informed consent was sought and obtained from their parents or legal guardians. The programme of the study was approved by the Ethical Research Committee at the Institute of Sports in Warsaw.

The test exercise consisted of running until exhaustion on a mechanical treadmill with the workload being increased every five minutes by 2 km per hour. The consecutive elevations of the workloads, which were adjusted individually so that the whole time of the run until exhaustion would range from 15 to 25 min, were separated by one-minute breaks. Heart rate was registered using the Polar Sports Tester (Polar Electro, Oy, Finland). Arterialised blood samples were collected from the fingertips and used for determination of blood lactate concentration with the enzymatic method (Boehringer-Mannheim tests, Germany), and the indices of the acid-base equilibrium, with use of the Corning-278 analyser. Pulmonary ventilation (VE) and indices of the gas exchange were recorded in an

open system using the MMC Beckman detector. For estimation of VO_2max the following criteria were employed:
- plateaued VO_2 despite the increase in the workload;
- the post-exercise lactate concentration in blood exceeding 8 $mmol \cdot l^{-1}$;
- respiratory quotient (RQ) in excess of 1.10;
- maximal heart rate adequate to age (as calculated from the formula: HR_{max} = 220 – years of age).

Oxygen uptake was regarded as maximal if at least two of the above criteria were fulfilled during the exercise [5]. The lactate threshold indices (OBLA) were calculated based on the relation between the running speed (V), oxygen uptake (VO_2), or heart rate (HR) and the blood lactate level with use of the method of interpolation to the lactate concentration of 4 $mmol \cdot l^{-1}$. Maximal running speed (V_{max}) was calculated according to the formula:

$$V_{max} = (t_1/t_2) \cdot \Delta V + V$$

where: t_1 is the time of the last exercise until exhaustion,
t_2 is the assumed time of exercising (5 min),
ΔV is the increase in the speed of running (2 $km \cdot h^{-1}$),
V is the running speed in the last but one exercise.

Running economy (RE) was calculated based on VO_2 (in $ml \cdot kg^{-1} \cdot min^{-1}$) at the speed of V_{OBLA} and expressed as the VO_2 value in mL per kg body mass per km.

Statistical analysis. Statistical significance of the mean changes (Δ) of the studied indices over one year was estimated using the Student's t test for dependent data. For the assessment of the influence of age on the mean values of the indices obtained in the second run of the study analysis of variation (ANOVA) was used. Significance of the differences between means was assessed with use of the Newman-Keuls test. Additionally, the direct Pearson correlation coefficients between the subject's age and the examined indices were calculated. The differences between means were regarded significant at $P<0.05$. The data in the text and the tables are presented as means ±SD, and in the figures as means ±SE.

Results

Fig. 1 through 10 show means of individual annual changes in the tested indices across all the age groups. The means for the best ten male and six female orienteers examined in the years 1990-2000 and divided into four age groups are presented in Tables 1 and 2.

As indicated in Fig. 1, significant annual increases in body mass occurred in the male athletes aged 16-23 years. Likewise, the body mass of the female subjects of the same age increased or tended to increase. As shown in Figs. 2 and 3, V_{OBLA} and Vmax tended to increase in the males aged 16-19 years, whereas no marked similar tendencies were noted in the respective group of females. Fig. 4 shows that running economy expressed as the oxygen uptake (in $ml \cdot kg^{-1} \cdot km^{-1}$) improves between 15 and 17 years of age in females, and between 16 and 18 years of age in males. VO_2max (in $l \cdot min^{-1}$) increased only in the boys aged 16-17 years (Fig. 5) but in the girls from the same age group this index also tended to increase. No significant alterations of VO_2max relative to the body mass could be detected in any female and male age group (Fig. 6). In the females aged 15-19 years and the males aged 16-19 years VO_{2OBLA} (expressed in $l \cdot min^{-1}$) tended to increase (Fig. 7). The value of this index related to the body mass ($ml \cdot kg^{-1} \cdot min^{-1}$) decreased in the girls aged 16-17 years and then increased again in the girls aged 17-18 years (Fig. 8) but no significant changes in VO_{2OBLA} were detectable in the respective groups of the boys. In the athletes older than 23 years of age, physical fitness tended to decrease.

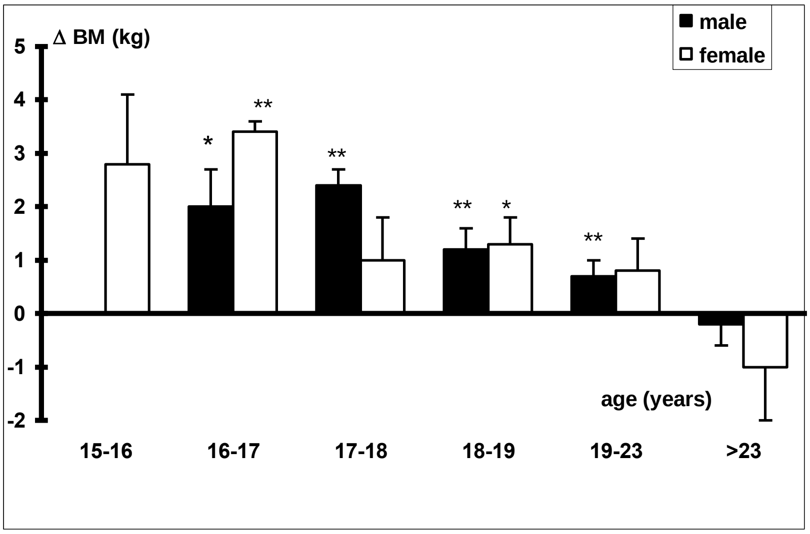

Fig. 1
Annual changes in the body mass in relation to age in orienteers, members of the Polish National Team
*P<0.05, **P<0.01

Table 1
Mean values of the selected parameters of physical fitness obtained in the period from 1990 to 2000 in the elite male orienteers in different age groups (mean ±SD)

Groups Age (years)	Group I 16.0-18.0	Group II 18.1-20.0	Group III 20.1-24.0	Group IV >24.1
Body mass (kg)	64.1±4.7	63.1±3.5	64.5±6.2	66.0±6.5
V_{OBLA} ($km \cdot h^{-1}$)	16.5±1.4	17.6±1.1	17.5±1.0	17.9±0.9
HR_{OBLA}($b \cdot min^{-1}$)	183±12	181±8	180±7	176±7
VO_{OBLA} ($l \cdot min^{-1}$)	3.84±0.34	4.11±0.27	3.97±0.35	4.16±0.42
VO_{OBLA} ($ml \cdot kg^{-1} \cdot min^{-1}$)	59.9±3.5	65.3±4.2*	61.8±4.9	63.2±3.2
V_{Emax} ($l \cdot min^{-1}$)	148±13	153±19	155±16	160±17
VO_{2max} ($l \cdot min^{-1}$)	4.63±0.40	4.86±027	4.85±036	5.01±0.50
VO_{2max} ($ml \cdot kg^{-1} \cdot min^{-1}$)	72.2±4.3	77.1±4.4	75.4±4.5	76.1±4.7
HR_{max} ($b \cdot min^{-1}$)	199±9	195±8	195±7	191±7
LA_{max} ($mmol\ l^{-1}$)	11.2±1.9	11.1±2.2	11.0±2.5	11.6±1.9
pH	7.22±0.05	7.21±0.05	7.22±0.06	7.20±0.06
BE_{max} ($mmol\ l^{-1}$)	-13.5±2.4	-13.6±2.6	-13.6±2.9	-14.4±3.3
Vmax ($km \cdot h^{-1}$)	19.6±0.8	20.5±0.9*	20.7±1.1*	21.0±0.7*
RE ($ml \cdot kg^{-1} \cdot h^{-1}$)	218±12	223±12	212±15	210±11

*indicates significant ($P<0.05$) differences from the mean obtained in the first age group

In fact, mean annual changes in VO_2max and in VO_2max relative to body mass (which were statistically insignificant) equalled to –0.09±0.23 $l \cdot min^{-1}$ and –0.6±3.2 $ml \cdot kg^{-1} \cdot min^{-1}$, respectively, in the females, and to -0.05±0.17 $l \cdot min^{-1}$ and –0.5±3.4 $ml \cdot kg^{-1} \cdot min^{-1}$, respectively, in the males. Likewise, mean annual alterations in VO_{2OBLA} and in VO_{2OBLA} relative to body mass (also statistically insignificant) equalled to –0.09±0.23 $l \cdot min^{-1}$ and to -0.7±3.9 $ml \cdot kg^{-1} \cdot min^{-1}$, respectively, in the females, and to -0.04 $l \cdot min^{-1}$ and to 0.1±4.7 $ml \cdot kg^{-1} \cdot min^{-1}$, respectively, in the males.

Table 2
Mean values of the selected parameters of physical fitness obtained in the period from 1990 to 2000 in the elite female orienteers in different age groups (mean ±SD)

Groups Age (years)	Group I 16.0-18.0	Group II 18.1-19.0	Group III 19.1-23.0	Group IV >23.1
Body mass (kg)	57.3±2.3	56.2±6.6	53.0±4.4	55.1±4.6
V_{OBLA} ($km \cdot h^{-1}$)	14.2±0.5	14.0±1.0	14.4±1.1	15.1±0.2
HR_{OBLA}($b \cdot min^{-1}$)	183±6	181±15	186±8	177±9
VO_{OBLA} ($l \cdot min^{-1}$)	3.00±0.11	2.94±0.42	2.88±0.25	3.05±0.37
VO_{OBLA} ($ml \cdot kg^{-1} \cdot min^{-1}$)	52.4±1.3	52.2±4.0	54.6±3.4	55.3±2.9
V_{Emax} ($l \cdot min^{-1}$)	117±7	115±14	112±13	102±13
VO_{2max} ($l \cdot min^{-1}$)	3.66±0.28	3.63±0.37	3.53±0.32	3.54±0.48
VO_{2max} ($ml \cdot kg^{-1} \cdot min^{-1}$)	64.0±2.7	64.8±4.4	66.7±3.4	64.1±3.7
HR_{max} ($b \cdot min^{-1}$)	198±5	201±10	201±5	192±10
LA_{max} ($mmol \cdot l^{-1}$)	10.9±1.0	11.2±1.2	11.5±1.7	9.4±1.3
pH	7.21±0.05	7.23±0.05	7.20±0.06	7.25±0.07
BE_{max} ($mmol \cdot l^{-1}$)	-14.2±2.6	-14.3±2.4	-15.7±1.9	-12.7±2.2
Vmax ($km \cdot h^{-1}$)	16.8±0.6	17.0±0.7	17.4±1.0	17.3±0.3
RE ($ml \cdot kg^{-1} \cdot h^{-1}$)	221±9	225±15	228±14	219±13

No significant one-way changes with age in the maximal exercise ventilation were detected in the tested subjects (Fig. 9), although in the males aged 16-21 years the index tended to increase. Likewise, no significant alterations in the maximal heart rate could be found (Fig. 10) and only a tendency for the to age-related decrease in this index was recorded in the females.

Similar conclusions to the above can be drawn based on the results of the analysis of data obtained in the best male and female orienteers divided into the age groups (Tables 1 and 2). The only exception is the mean body mass which did not tend to increase in the athletes from the older age groups, assumingly due to the suspension between 16 and 18 years of age of the training by some male and female athletes demonstrating good physical fitness and the relatively large body masses. In spite of that, in the males VO_2max (expressed in $l \cdot min^{-1}$) tended to slightly increase and weakly correlated with the age (r=0.32; P<0.05).

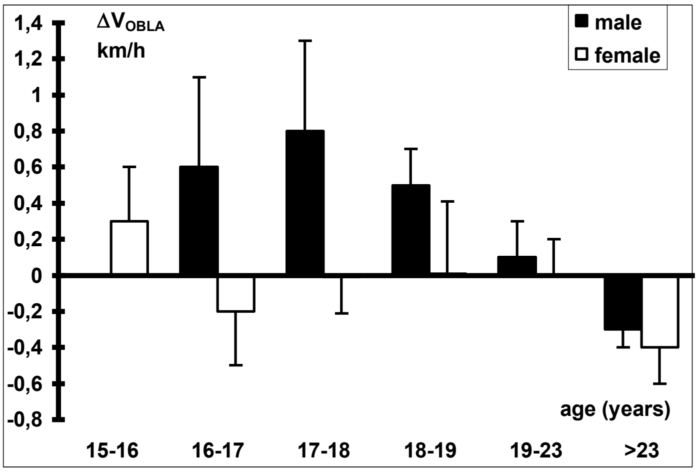

Fig. 2
Annual increments in the speed at the lactate threshold in relation to age in orienteers, members of the Polish National Team

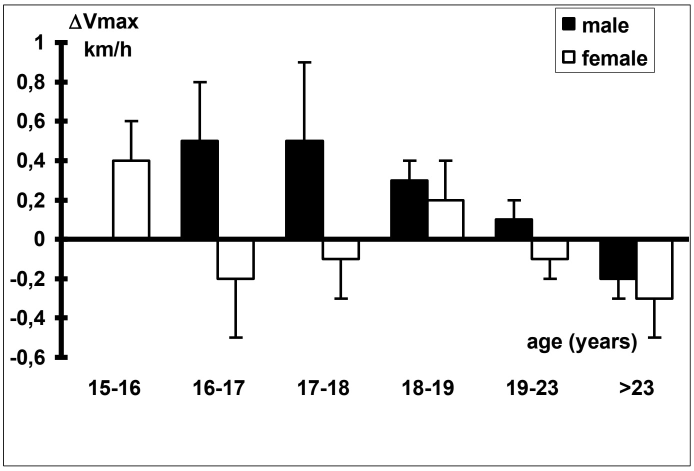

Fig. 3
Annual increments in the maximal speed in relation to age in orienteers, members of the Polish National Team

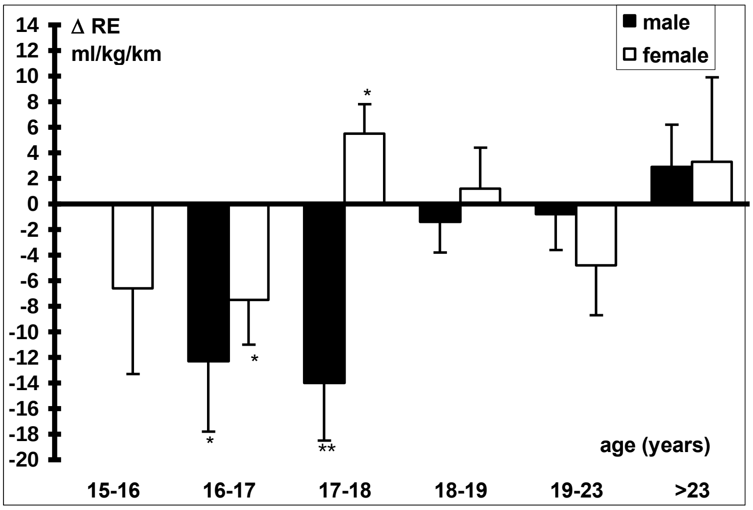

Fig. 4
Annual changes in the running economy in relation to age in orienteers, members of the Polish National Team; *P<0.05, **P<0.01

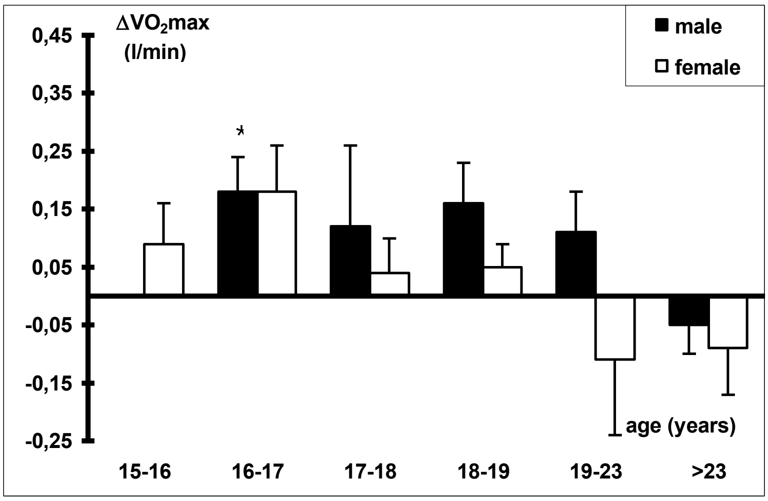

Fig. 5
Annual increments in the maximal oxygen uptake ($l \cdot min^{-1}$) in relation to age in orienteers, members of the Polish National Team; *P<0.05

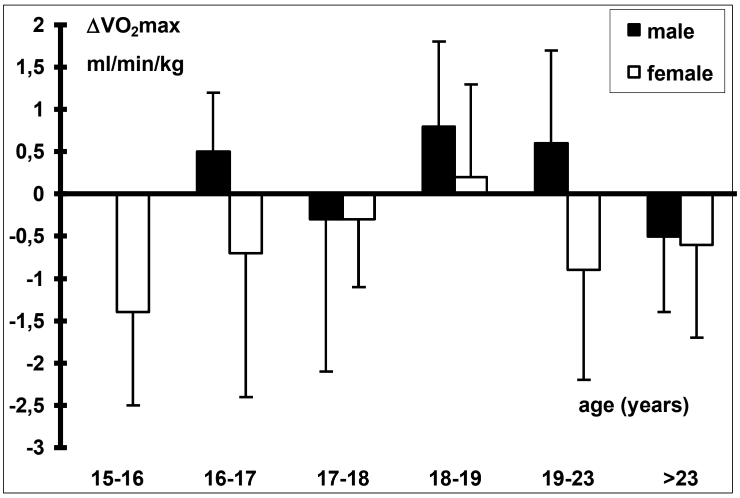

Fig. 6
Annual increments in the maximal oxygen uptake ($ml \cdot kg^{-1} \cdot min^{-1}$) in relation to age in orienteers, members of the Polish National Team

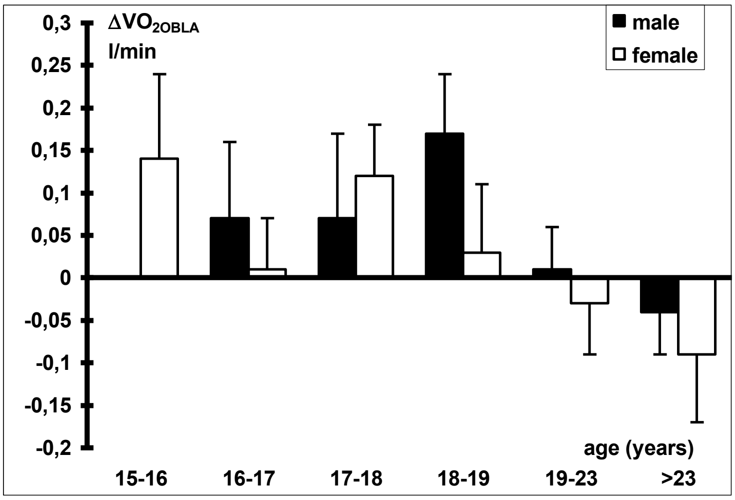

Fig. 7
Annual increments in the oxygen uptake ($l \cdot min^{-1}$) at the lactate threshold in relation to age in orienteers, members of the Polish National Team

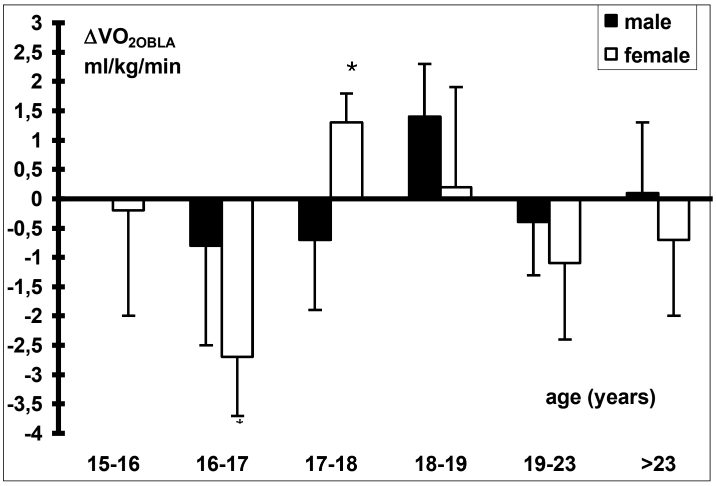

Fig. 8
Annual increments in the oxygen uptake (ml·kg^{-1}·min^{-1}) at the lactate threshold in relation to age in orienteers, members of the Polish National Team; *P<0.05

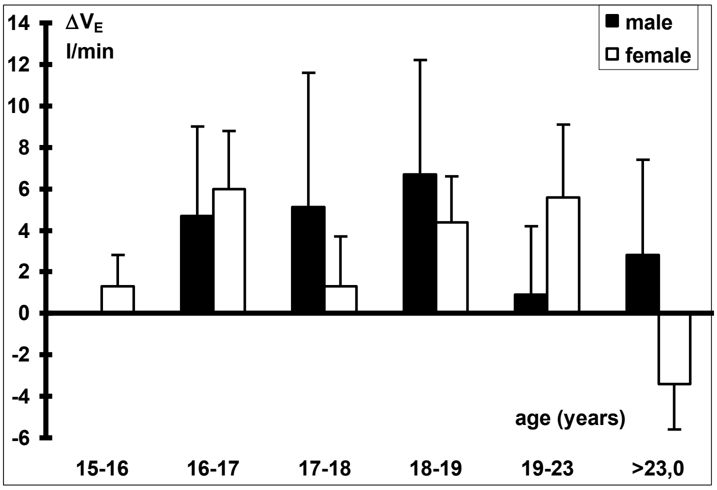

Fig. 9
Annual increments in the maximal pulmonary ventilation in relation to age in orienteers, members of the Polish National Team

As was the case during the first run of the study, no alterations in VO_2max relative to body mass as well as no significant one-way changes in VO_{2OBLA} were found. The male athletes tended to demonstrate age-related increases in the mean values of Vmax and V_{OBLA}. The values of V_{OBLA} in group 4 and of Vmax in groups 2, 3, and 4 were significantly higher than in group 1. These values also correlated with the age of the male subjects (Vmax: r=0.5, P<0.01; V_{OBLA}: r=0.34, P<0.05) but in the females only the V_{OBLA} values correlated with age (r=0.44, P<0.05). No significant differences in RE were found although in the males a significant negative correlation between this index and the age (r=-0.4, P<0.05) was detected. With neither of the two methods of analysis, the clearly defined alterations in the heart rate at the lactate threshold, maximal pulmonary ventilation, post-exercise blood lactate concentration, pH, and excess base content (BE) could be detected. The maximal heart rate decreased with age (Fig. 10) although, due to small annual alterations in the values of this index relative to the mean HRmax values and a considerable dispersion of the results, the changes were not statistically significant. The mean annual decrease in HRmax equalled to 0.69±4.0 beats per minute in the male and to 1.5±4 beats per min. in the female orienteers.

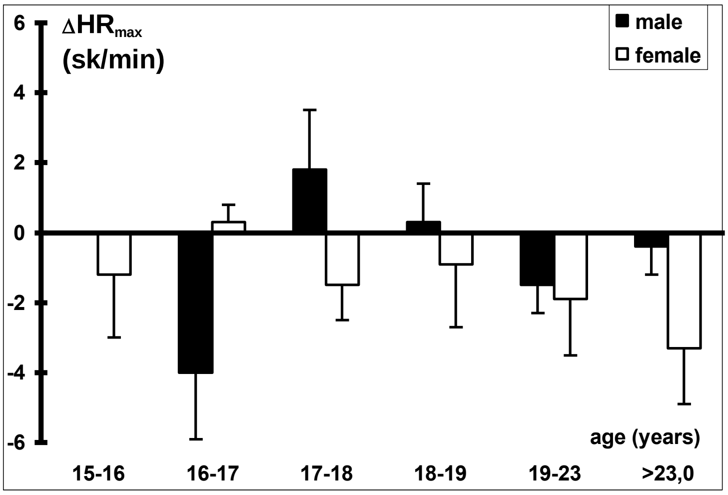

Fig. 10
Annual increments in the maximal heart rate in relation to age in orienteers, members of the Polish National Team

Discussion

Young Polish orienteers, even those from the national elite, sometimes break in on their training schedules because of burdens imposed by the demands of a job or school studies. As a result, we were unable to collect a representative group of subjects to conduct the longitudinal study. On the other hand, due to the more frequent suspension of the training by the unsuccessful compared to the successful athletes, cross-sectional investigations are usually error-prone and, because of the gradual elimination of the weaker athletes, tend to yield elevated values of the fitness indices in groups of the older subjects. In order to avoid this error, we employed in the present study two methods of the analysis of changes in the tested indices. The first method was used to analyse, as in the longitudinal studies, mean individual, age-related alterations per year of the tested indices. In the second run of the study, we analysed the results obtained in the male and female orienteers who – in a given age group – presented with the best indices of physical fitness over the period of ten years. With this approach, we were able to disregard the weaker athletes who, due to the lack of successes in sports, were likely to suspend their training. Both methods of the analysis revealed either comparable changes, tendencies towards the changes or – most often – no alterations in the values of the tested indices, the only exception being changes in the body masses. With respect to the last index, more reliable appear to be the results obtained in the first part of the study in which, based on the annual changes demonstrated in individual subjects, we were able to detect the age-related weight gain. In fact, it was impossible in the second run to avoid the error related to the suspension of the training by a few female and even fewer male orienteers exhibiting the relatively good physical fitness but also the greater body mass compared to the remaining subjects under study.

Orienteering is a sport requiring a considerable running endurance. In case of good orienteers, the running time on the classical distance equals to about 65 min for the females and 90 min for the males, whereas the short distance is covered by these athletes in 20-25 minutes. The running speed depends on the configuration of the terrain and, on the classical distance, is generally commensurate with the workload at which blood lactate level approaches four $mmol \cdot l^{1}$, heart rate remains at about 90% of the maximum, and oxygen uptake amounts to 85-90% of VO_2max [3,12]. Such an effort requires a high aerobic capacity. Consequently, the values of VO_2max related to the orienteers' body mass count among the highest recorded in the athletes from different sports [7,8,14,16]. Physical fitness of the Polish orienteers approximates that of the world elite representatives in this game. In the present study, the highest mean VO_2max value of 77.1 $ml \cdot kg^{-1} \cdot min^{-1}$ was recorded in the male subjects aged between 18.1 and 20 years. Comparable values of 78.4 and 74.3 $ml \cdot kg^{-1} \cdot min^{-1}$ were detected by Rolf *et al.* [14] and by Jensen *et al.* [7] in the Swedish and the Danish orienteers, respectively. In females, the highest mean value of VO_2max of 66.7 $ml \cdot kg^{-1} \cdot min^{-1}$ was noted by us in the subjects aged between 19.1 and 23 years; this value approximated that reported by Rolf *et al.* [14] for the Swedish athletes (68.0 $ml \cdot kg^{-1} \cdot min^{-1}$) and exceeded that detected by Jensen *et al.* [7] in the Danish orienteers (59.0 $ml \cdot kg^{-1} \cdot min^{-1}$).

The most important finding of the present study is the lack of significant changes in the physical fitness between the age of 16 and 23-28 years in the male, and between 15 and 23-29 years in the female orienteers. The males aged 16-17 years exhibited only a slight increase in VO_2max (in $l \cdot min^{-1}$) with age and those aged 16-18 years tended to demonstrate the age-related increases in V_{OBLA}, Vmax, and VO_{2OBLA}. Likewise, the females aged 15-19 years tended to exhibit the age-related increases in VO_{2OBLA} and V_{OBLA}. In both the female and male subjects, neither VO_2max nor VO_{2OBLA} related to the body mass changed during the investigation period. De Koning *et al.* [2] reported similar results from their studies on changes in VO_2max in speed skaters aged between 16-17 and 20-21 years. These authors did not demonstrate any changes in VO_2max related to the body mass either in the male or female athletes under study and only the absolute values of VO_2max increased proportionally to the elevation in the body mass of the subjects successful in sports. Likewise, Ingjer [4] demonstrated the rise in VO_2max (in $ml \cdot kg^{-1} \cdot min^{-1}$) in cross-country skiers younger than 15-16 years although the increase in the oxygen uptake (in $l \cdot min^{-1}$) was detectable in these athletes up to 20 years of age. In turn, no increase in VO_2max (in $ml \cdot kg^{-1} \cdot min^{-1}$) could be demonstrated in tennis players beyond the age of 12 years [4]. In contrast, Murase *et al.* [11] found that in six high-class runners VO_2max (expressed both in $l \cdot min^{-1}$ and $ml \cdot kg^{-1} \cdot min^{-1}$) increased between 14.8 and 18 years of age. Rusko [15] showed that in Finnish cross-country skiers aged 15 to 20 years the annual increase in VO_2max equalled to 1-3 $ml \cdot kg^{-1} \cdot min^{-1}$. Moreover, in the same investigation carried out on the world leading cross-country skiers the increase in VO_2max relative to body mass accompanied by the similar elevation in the threshold oxygen uptake was detected in subjects aged between 20 and 24 years. The rise in the maximal and threshold oxygen uptakes detectable in the Finnish elite cross-country skiers even beyond the age of 20 years is probably associated with the age-related increase in the amount and intensity of the training. As indicated by Rusko [15], the training load increases from 50 km per week scheduled for the 15-year-old

Finnish cross-country skiers to 100 km per week and 140-150 km per week for those aged 20 and 25 years, respectively.

Similar to cross-country skiing, orienteering is a game in which the training, apart from developing the technique, is aimed at generating the running endurance and aerobic capacity. Hence, one can assume that the appropriate elevation of the intensity and the amount of the training of the subjects between 20 and 25 years of age might lead to the improvement of physical fitness of the orienteers examined by us comparable to that described by Rusko [15]. However, in view of the findings of another study of the leading Scandinavian cross-country skiers who did not exhibit any increase in their VO_2max (in $ml \cdot kg^{-1} \cdot min^{-1}$) beyond the age of 16-17 years [6], the above assumption can no longer stand out as self-evident.

On the other hand, in contrast to the findings reported for people not professionally engaged in sports [1,17] and similarly to those obtained earlier in tennis players [4], no decrease in VO_2max relative to body mass could be demonstrated in the present study in the orienteers younger than 23 years. The herein described tendencies for VO_2max and HRmax to decrease in the orienteers older than 23 years (by 0.5 $ml \cdot kg^{-1} \cdot min^{-1}$ per year for the males and by 0.6 $ml \cdot kg^{-1} \cdot min^{-1}$ per year for the females and by 0.7 b min^{-1} per year for the males and by 1.5 $b \cdot min^{-1}$ per year for the females, respectively) are comparable to those reported from studies carried out on subjects demonstrating high physical activity. In those studies, annual decreases in VO_2max and HRmax by as much as from 0.4 $ml \cdot kg^{-1} \cdot min^{-1}$ to 0.8 $ml \cdot kg^{-1} \cdot min^{-1}$ [10,13,18] and from 0.8 to 1.0 $b \cdot min^{-1}$ [9], respectively, were demonstrated.

In conclusion, the obtained results demonstrate that in male and female representatives of such an endurance sport as orienteering the increase in the values of the aerobic capacity indices with increasing age of the subjects is relatively early suppressed In spite of this, the present results indicate that physical fitness of the Polish elite orienteers is comparable to that of their Scandinavian counterparts.

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Accepted for publication 24.02.2003