Brit. J. Sports Med. — Vol. 12, No. 2, June 1978, pp. 87-92

A STUDY OF POTENTIAL OLYMPIC SWIMMERS

PART 2
CHANGES DUE TO THREE MONTHS INTENSIVE TRAINING

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ABSTRACT

Anthropometric and physiological measurements were recorded for a group of exceptional young swimmers undergoing an intensive training programme over 3 months. The observed changes are presented and are discussed in relation to the training undertaken, and are compared with expected changes due to normal growth. Some of the physiological parameters measured showed marked changes: average physical work capacity decreased significantly, while the physical fitness index improved. Many of the anthropometric changes were small, but a significant increase in lean body mass occurred in both boys and girls, and in both groups the average weight gain was greater than that expected. In individuals subjected to rigorous training significant changes in anthropometric and physiological parameters over and above the expected changes due to normal growth and development occur relatively quickly within a period of 3 months.

INTRODUCTION

In recent years several changes have occurred in the training of young swimmers. These young children now commence swimming training at an earlier age than in the past, and they are also expected to train more intensively for longer periods. The effects of such training on pubertal children is not well documented. Cunningham and Eynon (1975) have stressed the need for the collection of longitudinal data so that the effects of this training can be assessed accurately.

In a previous paper (Bagnall and Kellett, 1977) we outlined the present project which is concerned with the longitudinal monitoring of a group of highly successful, competitive swimmers who are undergoing a very intensive training programme. In this paper we compare the results of two monitoring periods 3 months apart and discuss the anthropometric and physiological changes that have occurred.

SUBJECTS AND METHODS

The subjects consisted of 9 girl swimmers (average age at first session 15.7 yr) and 6 boys (average age at first session 15.5 yr) who were all members of the City of Manchester Swimming Club, an exclusive club which encourages competitive swimming of a high standard. The two sessions of monitoring were at Christmas 1976 and Easter 1977. There were ten weeks of training before Christmas 1976, and on average the subjects swam 60 km/week, an average distance of 6,000 metres/session, 10 sessions per week. There was also a ten week period of training before Easter 1977, when on average the subjects swam 48 km/week, an average of 6,000 metres/session, 8 sessions per week. There were no substantial differences in the types of training undertaken in the two programmes before Christmas and Easter. During the 6 month period covered by both programmes, however, the training sessions were more rigorous than those in previous programmes; the boys and particularly the girls were committed to training which lasted longer and was more strenuous.

The methods by which the anthropometric and physiological measurements were made have been described in detail (Bagnall and Kellett, 1977).

RESULTS

The anthropometric and physiological measurements obtained at the two monitoring sessions from the boys and girls were compared with each other. The results were subjected to statistical analysis to determine the significance of the changes observed (Tables I, II, III, IV). Since the monitoring sessions were three months apart, some changes would be expected as a result of normal growth and development. The observed changes were compared with the expected changes, where normal standards for growth and development were available (Tanner, 1962). (Table V).

TABLE I

Comparison of the anthropometric measurements taken at Christmas and Easter for the six BOYS

Parameter	Mean Difference between Christmas and Easter	Standard Error of Mean Difference	Student's T	Probability of T > "T" with n-1 degrees of freedom
Vital capacity l	0.13	0.17	0.77	0.520
Biceps mm	–0.12	0.34	–0.34	0.744
Triceps mm	–0.10	0.29	–0.34	0.743
Subscapular mm	0.27	0.09	3.02	0.029*
Supra-iliac mm	–0.62	0.65	–0.94	0.608
Weight kg	1.3	0.64	2.04	0.096
Height cm	0.98	0.32	3.06	0.028*
Upper arm circumference cm	0.82	0.31	2.66	0.044*
Maximum calf circumference cm	0.77	0.31	2.47	0.056
Bi-acromial diameter cm	–0.10	0.13	–0.75	0.506
Bi-iliocristal diameter cm	0.12	0.11	1.08	0.329
Sum of 4 fats mm	–0.57	0.97	–0.59	0.590
Body density	0.00067	0.001	0.63	0.559
Body fat %	–0.27	0.46	–0.58	0.593
Absolute body fat kg	0.05	0.34	0.15	0.883
Lean body mass kg	1.27	0.44	2.89	0.034*

****Indicates significance at 5% level***

TABLE II

Comparison of the anthropometric measurements taken at Christmas and Easter for the nine GIRLS

Parameter	Mean Difference between Christmas and Easter	Standard Error of Mean Difference	Student's T	Probability of T > "T" with n-1 degrees of freedom
Vital capacity l	0.44	0.12	3.72	0.006*
Biceps mm	–0.02	0.35	–0.06	0.95
Triceps mm	0.78	0.47	1.63	0.137
Subscapular mm	0.63	0.18	3.59	0.007*
Supra-iliac mm	0.57	0.17	3.40	0.009*
Weight kg	1.67	0.23	7.18	0.0002*
Height cm	0.53	0.25	2.10	0.067
Upper arm circumference cm	0.64	0.12	5.21	0.001*
Maximum calf circumference cm	0.84	0.11	7.50	0.0003*
Bi-acromial diameter cm	–0.03	0.25	–0.13	0.891
Bi-iliocristal diameter cm	0.41	0.16	2.59	0.031*
Sum of 4 fats mm	1.96	0.74	2.64	0.029*
Body density	–0.0016	0.00063	–2.48	0.037*
Body fat %	0.68	0.28	2.44	0.039*
Absolute body fat kg	0.74	0.17	4.32	0.003*
Lean body mass kg	0.92	0.23	3.93	0.005*

****Indicates significance at 5% level***

TABLE III

Comparison of the physiological measurements taken at Christmas and Easter for five BOYS

Parameter	Mean Difference between Christmas and Easter	Standard Error of Mean Difference	Student's T	Probability of T > "T" with n-1 degrees of freedom
% recovery 1 minute	4.0	1.26	3.16	0.035*
% recovery 2 minutes	0.0	1.96	0.31	0.77
% recovery 3 minutes	3.0	2.14	1.40	0.23
PWC 170 W	−39.0	5.7	6.80	0.004*
PWC 170 W/kg body weight	−0.70	0.11	−6.33	0.005*
PWC 170 W/kg lean body mass	−0.83	0.13	−6.45	0.004*
Fitness index	18.0	5.0	3.59	0.024*
Max measured $\dot{V}O_2$ l/min	−0.70	0.17	−4.05	0.025*
Max measured $\dot{V}O_2$ ml/min/kg lean body mass	−14.8	3.60	−4.11	0.024*
Predicted max $\dot{V}O_2$ l/min	−0.42	0.23	−1.86	0.136
Predicted max $\dot{V}O_2$ ml/min/kg lean body mass	−9.88	4.34	−2.28	0.085
Oxygen pulse ml/beat	−4.35	1.01	−4.31	0.021*
Working max %	−9.0	3.49	−2.58	0.081

**Indicates significance at 5% level*

DISCUSSION

Anthropometric changes

Parizkova and Carter (1976) followed the progress of 39 adolescent boys for 8 years. The boys were placed in one of 3 subgroups according to their level of activity and were somatotyped annually using the Heath-Carter method. There were no changes in the somatochart distributions of the group as a whole, but there were considerable individual changes, all the boys changing their ratings at least once and 67% changing in component dominance. The somatotype changes migratory distances showed considerable variation and Parizkova and Carter (1976) concluded that changes in somatotypes can occur during adolescence.

In this study, 50% of the male swimmers did not change their somatotype ratings. Changes of ½ unit were observed in one swimmer who changed one component and two swimmers who changed two components. However, changes of only ½ unit might be due to errors in measurement. Only one boy swimmer changed his somatotype rating by one whole unit from 1½-4-4 to 1½-5-3½; probably this was due to an increase in muscle mass, since measurements of both upper arm circumference (29.1 cm – 30.7 cm) and maximum calf circumference (33.4 cm – 35.5 cm) increased considerably. The mesomorphic component was dominant for all the boys at both sessions and with only one exception the endomorphic component achieved lowest scores.

Only one of the girls maintained the same somatotype rating. Changes of ½ unit were observed in 5 who changed in one component, 2 who changed in two components and 1 who changed in all three components. However, only one girl changed her somatotype rating

TABLE IV

Comparison of the physiological measurements taken at Christmas and Easter for seven GIRLS

Parameter	Mean Difference between Christmas and Easter	Standard Error of Mean Difference	Student's T	Probability of T > "T" with n-1 degrees of freedom
% recovery 1 minute	4.4	2.9	1.54	0.172
% recovery 2 minutes	0.43	3.2	0.13	0.890
% recovery 3 minutes	−0.71	1.9	−0.38	0.718
PWC 170 W	−63.8	20	−3.17	0.019*
PWC 170 W/kg body weight	−1.3	0.35	−3.61	0.011*
PWC 170 W/kg lean body mass	−1.6	0.43	−3.75	0.010*
Fitness index	2.7	8.3	0.33	0.750
Max measured $\dot{V}O_2$ l/min	−0.50	0.1	−3.85	0.192
Max measured $\dot{V}O_2$ ml/min/kg lean body mass	−12.6	3.1	−4.11	0.159
Predicted max $\dot{V}O_2$ l/min	−0.72	0.1	−6.51	0.001*
Predicted max $\dot{V}O_2$ ml/min/kg lean body mass	−18.67	2.3	−8.10	0.001*
Oxygen pulse ml/beat	−2.42	0.8	−2.87	0.046*
Working max %				∞

**Indicates significance at 5% level*

by a whole unit from 2-3½-3 to 3-4-3½; this increase in endomorphic component was due to an increase in the total of the four skinfold thicknesses (26.8 mm to 32.8 mm). The mesomorphic component was dominant in 56% of the girls and in 44% the ectomorphic component was dominant. There were no changes in the somatotype component which was dominant.

Table I shows that for the boys significant differences between the two monitoring sessions were observed on only four parameters; height, subscapular skinfold thickness, upper arm circumference, and lean body mass; all showed significant increases. The expected increase in height due to normal development (Table V) is 0.7 cm and the observed average increase in height was 1.0 cm (Table V). There is no evidence that training has had a marked effect on the height of the boy swimmers. The expected increases in bi-acromial and bi-iliocristal diameters were 3.0 mm and 1.5 mm respectively (Table V) but the observed average changes were small and not significant (Table V). If skeletal changes do result from training, these changes may be detected over a longer period of study and we hope to be able to comment further upon this later.

The average increase in weight of the boys by 1.3 kg is unlikely to consist of fat since there was an overall average decrease in the total of the four skinfold thicknesses. The gain in weight appeared to be due to a change in lean body mass (LBM), which increased significantly. The changes in the measurements of muscle girth (upper arm and maximum calf circumference, Table I) support the interpretation that the average increase in weight, almost twice that expected, was due to increased muscle mass. The indication is that this is due to the effect of training.

TABLE V

Comparison of the observed and expected differences between the two monitoring sessions

PARAMETER	GIRL SWIMMERS (9)		BOY SWIMMERS (6)	
	average difference	expected difference	average difference	expected difference
Height cm	0.5	0.1	1.0	0.7
Weight kg	1.7	0.1	1.3	0.7
Bi-acromial diameter mm	−0.3	1.0	−1.0	3.0
Bi-iliocristal diameter mm	0.4	1.0	0.1	1.5
Triceps skinfold mm	0.8	0.2	−0.1	0.1
Subscapular skinfold mm	0.6	0.1	0.3	0.2
Vital capacity (Cotes, 1968)	0.4	0.03*	0.1	0.07†

**Girls, average height at Christmas 165.8 cm, at Easter 166.3 cm*
†Boys, average height at Christmas 170.8 cm, at Easter 171.8 cm

For the girls, significant changes were found in 12 of the 16 parameters measured (Table II); they mature more quickly than boys (Tanner, 1962) and, as expected, a smaller increase in height was observed for the girl swimmers. Bi-acromial and bi-iliocristal diameters also reach adult proportions more quickly in girls than boys, and only small increases were expected as a result of normal development. However, the average increase of 4 mm in the bi-iliocristal diameter was much greater than expected. This may represent a genuine increase in bone development, but the values are probably distorted by the significant increase in supra-iliac skinfold thickness (Table II). Any change in the thickness of adipose tissue overlying the iliac tubercles may influence the measurement of the bi-iliocristal diameter, but the extent to which the observed increase in bi-iliocristal diameter is due to an increase in supra-iliac fat cannot be assessed accurately.

On average the girl swimmers increased in weight by 1.7 kg. The expected increase in weight was considerably less than that observed (Table V). This increase was due to significant increases in both LBM and absolute body fat. That there was an increase in muscle mass is shown by the significant changes in direct muscle girth measurements of the upper arm and the calf. Changes in the upper arm skinfold thickness measurements were not significant. Increase in body fat is illustrated by the significant increases in the measurements of both the subscapular and supra-iliac skinfold thicknesses. The subscapular skinfold thickness measurements also increased significantly in the male swimmers. It is difficult to suggest reasons why fat should be deposited in these regions in particular and not in other regions. We suspect that the changes in LBM are due to the rigorous training undertaken by these girls.

There was an interesting change in the vital capacities of the girl swimmers. The average increase of 0.44 litres represented an increase of 10% and was considerably greater than that expected as a result of normal development (Table V). No similar change was observed in the boys. The amount of training undertaken during the six months before the second assessment was greater than that undertaken previously for both the boys and girls, but the increase was proportionately greater for the girls. It may be that the significant increase in the vital capacities of the girls represents a training effect.

Physiological changes

No consistent overall increase in physiological performance of these swimmers was demonstrated (Tables III, IV), and it is not possible to conclude that an overall improvement in fitness has been attained. Indeed, physical work capacity (PWC) has decreased for both boys and girls, indicating that the standardised work loads produced greater stress and poorer accommodation to that particular exercise. Gross PWC represented by PWC 170 showed a decrease of 23.4% for the combined groups. Group results also show decreases when PWC is related to LBM and body weight (Tables III, IV). The reduction in working capacity is most marked for the girls who show a drop of 27% between the two monitoring sessions. Values for oxygen uptake during exercise, and maximum oxygen uptake predicted using the Åstrand-Ryhming Nomogram (Åstrand and Rodahl, 1970), were both lower at Easter than at Christmas.

Predicted maximum oxygen uptake values for the boys fell from 3.56 l/min to 3.08 l/min, a decrease of 13.5%, and the values for the girls fell from 3.40 l/min to 2.69 l/min, a decrease of 20.9%. General cardio-respiratory functioning, as indicated by values for oxygen pulse (ml/beat) is also significantly lower at Easter for both boys and girls, largely as a result of a higher oxygen uptake for a given maximum heart rate.

These changes (reduction in PWC and reduced values for oxygen uptake and oxygen pulse) may be related to differences in the training programmes before the Christmas and Easter monitoring sessions. Before the Christmas monitoring session, the subjects were swimming on average 60 km/week but after Christmas swam on average 48 km/week. Before the Easter monitoring session less emphasis was placed on endurance capacity i.e. distance covered, and more emphasis was placed on "quality work-outs". This training programme allowed the swimmers to work at a lower percentage of their maximum endurance capacity and the average PWC fell, and despite the "quality" component, the programme failed to raise the max $\dot{V}O_2$ values.

ACKNOWLEDGEMENTS

We thank Mr. T. Tiffany of the Recreational Services Department, City of Manchester, for allowing us to monitor his swimmers, and Miss J. Lee and Mr. D. Lee for help in recording data.

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