Cardiorespiratory Training during Childhood and Adolescence

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Abstract

Increasing numbers of young people are participating in sports competitions (Sport England, 2003) and use training programmes to improve their cardiorespiratory (or aerobic) fitness as indicated by peak oxygen uptake (peak VO_2). This paper reviews the scientific bases of training programmes in young people and presents recommendations for training programmes appropriate for enhancing the peak VO_2 of children and adolescents from the age of 8-18 years. From the studies reviewed, 3 to 4 sessions per week, of 40 to 60 minutes duration, at an intensity of 85 to 90% of maximum heart rate, over a period of at least 12 weeks appears to be the minimum volume of exercise required to induce improvements in peak VO_2. Both children and adolescents are capable of increasing their peak VO_2 through appropriate exercise training and there is no evidence to suggest that there is a sex difference in responses.

Key Words: Age, Exercise Prescription, Maturation, Peak Oxygen Uptake, Sex

Introduction

The origins of this paper lie in an invitation to participate in the International Olympic Committee Medical Commission consensus statement meeting on "training the elite child athlete" in November 2005. At the end of the conference the expert committee agreed a consensus statement *(International Olympic Committee's Medical Commission, 2005)*. This consensus document provides, in addition to specific training recommendations, information on the principles of training for child athletes and issues related to overtraining. The intention of the document was to improve the health and safety of the elite child athlete through the promotion of safe training principles and increase awareness of these principles amongst the athlete's support team.

An increasing number of young people are now participating in sports competitions. In a survey conducted by Sport England in 2002, 61% of young people were found to take part in sports competitions in or out of school (Sport England, 2003). This represented a rise in participation rates of three percent above those reported in a survey conducted in 1999 and eight percent above those reported in 1994 *(Sport England, 2003)*. In order to improve their performances and chances of success in these competitions young people participate in many different training programmes. Unlike recommendations designed for adults, many of these training programmes are not based on strong scientific evidence.

Exercise prescriptions for improving adults' cardiorespiratory (or aerobic) fitness are well established *(American College of Sports Medicine, 1998)* and some authorities have recommended their application to young people *(Rowland, 1985; American College of Sports Medicine, 1988)*. However children and adolescents are not mini adults and as they grow and mature their physiological responses to physical activity and exercise develop as they progress to adulthood (for review see *Armstrong, 2006)*. Consequently, their responses to exercise training may also differ from those of adults.

Despite considerable research into children's and adolescents' responses to exercise training this area still warrants further investigation as small sample sizes and short-duration training programmes limit the extent to which the results of these studies may be generalised. Comparisons of young endurance athletes with non-training controls indicate expected aerobic training effects including increased maximal cardiac output, elevated blood and plasma volume and increased haemoglobin levels. During submaximal exercise reductions in heart rate with concomitant increases in stroke volume have been documented and there is evidence that trained young people exhibit larger myocardial mass and heart volume *(Armstrong and Welsman, 1997)*. Whether or not lung function is enhanced with endurance training in young people remains equivocal with some, but not all, studies indicating higher pulmonary capillarization and pulmonary diffusing capacity in trained individuals. Data on blood lactate responses to maximal and submaximal exercise are also inconclusive with some studies reporting improvements with training but methodological differences hamper comparisons between studies *(Armstrong and Welsman, 1997).*

Currently however, there are inadequate data to explore evidence-based, dose-response relationships between exercise training and cardiorespiratory outcome measures other than peak VO_2. This paper will therefore review studies that have investigated the effects of structured exercise training on peak VO_2. It is important to note that completion of an exercise training programme to optimise peak VO_2 does not necessarily translate into improved performance in endurance events. Successful performance requires a combination of elements such as speed, strength, flexibility and agility that combine to influence performance.

This paper reviews the scientific bases of exercise training in young people and presents training recommendations for enhancing cardiorespiratory (or aerobic) fitness as reflected by peak VO_2 for children and adolescents within the age range 8 to 18 years.

Method of Review

Relevant studies for review were located through computer searches of Medline, Sport Discus and personal databases, supplemented with an extensive search of bibliographies of accessed publications. Studies were only included in the analysis if they satisfied the following criteria.

- Published in the peer-review literature
- Participants were normal healthy young people
- Included both an experimental and a control group
- Provided a clear training prescription in terms of frequency, duration, intensity and programme length
- Participants were aged 8 years or above as the validity of directly determined peak VO_2 data from younger children is less secure *(Armstrong and Welsman 1997)*

Eighteen studies met the criteria and they are summarised in Tables 1 and 2. Table 1 describes studies of participants aged 8-10 years and Table 2 describes studies of participants aged 11-18 years.

The Effect of Age and Maturation on Responses to Training

It has been hypothesized that a maturational threshold exists whereby prepubescent children are unable to elicit physiological changes in response to training *(Gilliam and Freedson, 1980).* It has been proposed by *Katch (1983)* that there is a critical period in a child's life, a "trigger point", below which the effects of training will be minimal, or will not occur. It is believed that this trigger point is influenced by the modulating effects of hormones that initiate puberty and influence functional development and subsequent organic adaptations *(Katch, 1983).*

One study that supports this hypothesis followed a group of seven Japanese boys from the age of 9.7 – 15.8 years and determined their peak VO_2 annually *(Kobayashi et al., 1978).* The boys trained for 1 – 1.5 h per day, 4 or 5 times a week and engaged in various school based activities including endurance running, football and swimming. Peak VO_2 increased slowly in the boys until 1 year prior to peak height velocity after which peak VO_2 was found to increase above the normal increase attributable to age and growth (i.e. a greater increase was seen in the training group than in the control group). A major limitation of this study, however, was that measurements of peak VO_2 for the control group were not started until after the age of peak height velocity. Indirect supporting evidence for the "trigger point" hypothesis is provided by a study conducted by *Mirwald and colleagues (1981)* who measured peak VO_2 twice yearly in 25 boys from 7 – 17 years of age. From the beginning of the study peak VO_2 was found to be higher in the "active" boys compared with the "inactive" boys but this difference only reached statistical significance at peak height velocity.

In contrast with the findings of these studies, in an often cited report *Weber and colleagues (1976),* studied twelve pairs of identical twin boys where one twin trained and the other acted as his control. There were four sets of twins at each of 10, 13 and 16 years and the training twins followed the same 10-week programme. Percentage changes in the peak VO_2 of the trained boys were 23.5%, 14.2% and 20.5% at ages 10, 13 and 16 years respectively suggesting that the pre and post-pubertal periods were more amenable to training than circumpuberty. In a similar study, *Danis and colleagues (2003)* studied nine pairs of identical twin boys where one twin trained and the other acted as his control. An influence of training in the prepubertal but not in the pubertal twins was found. The findings of these two studies are in conflict with the view that more mature young people are more likely to improve aerobic fitness following training than those who have yet to reach puberty *(Katch, 1983).*

To address this issue, studies meeting the criteria for inclusion in this review were categorised into participants of either 8-10 years of age (Table 1) or 11-18 years of age (Table 2). Analysis of the studies in Tables 1 and 2 reveals that 6 of the 11 studies (55%) in Table 1 (participants <11 years) and 4 of the 7 studies (57%) in Table 2 (participants ≥ 11 years) reported significant increases in peak VO_2 with training. The average increase in mass-related peak VO_2 in studies in Table 1 was 6.5% (compared with an average control group change of – 0.4%) and in Table 2, 5.5% (control group 0.14%).

These figures represent a very crude overview of studies including different training programmes but they are in accord with the changes reported in reviews by Payne and Morrow (1993) and Le Mura and colleagues (1999).

Table 1. Exercise training and peak VO_2: studies with participants under 11 years of age

Study	Participants: Experimental (E)	Participants: Control (C)	Training protocol		Peak VO_2 $(L.min^{-1})$ Pre	Post	Change(%)	Peak VO_2 $(mL.kg^{-1}\cdot min^{-1})$ Pre	Post	Change(%)
Lussier & Buskirk (1977)†	n = 16 11 B 5 G 10.3 y	n = 10 9 B 1 G 10.5 y	**Frequency:** 4 days/wk **Intensity:** 92% max HR **Duration:** 45 min, **Length:** 12 wks **Type:** Continuous running & games	E	1.76	1.96	11.4	55.6	59.4	6.8 *
				C	1.83	1.96	7.1	53.1	53.9	1.5
Gilliam & Freedson (1980)	n = 11 B & G 8.5 y	n = 12 B & G 8.5 y	**Frequency:** 4 days/wk **Intensity:** HR at 165 beats·min^{-1} **Duration:** 14 - 21 min, **Length:** 12 wks **Type:** Enhanced PE programme	E	1.29	1.34	3.9	43.4	42.9	-1.2 NS
				C	1.34	1.40	4.5	40.5	40.9	1.0
Becker & Vaccaro (1983)	n = 11 B 9.6 y	n = 11 B 10.0 y	**Frequency:** 3 days/wk **Intensity:** 50% of the way between AT and peak VO_2 **Duration:** 40 min, **Length:** 8 wks **Type:** Continuous cycling	E	–	–	–	39.0	47.0	20.5 NS
				C	–	–	–	41.7	44.0	5.5
Savage *et al.* (1986)†	2 groups E_1 n = 12 B, 8.0 y E_2 n = 8 B, 8.5 y	n = 10 B, 9.0 y	**Frequency:** 3 days/wk **Intensity:** E_1 85% maxHR, E_2 68% maxHR **Duration:** 2.4 - 4.8 km, **Length:** 10 wks **Type:** interval running	E_1	–	–	–	55.9	58.5	4.7 *
				E_2	–	–	–	52.2	54.6	4.6 NS
				C	–	–	–	57.0	55.7	-2.3
Mc Manus *et al.* (1997)†	2 groups E_1 n = 12 G, 9.3 y E_2 n = 11 G, 9.8 y	n = 7 G, 9.6 y	**Frequency:** 3 days/wk **Intensity:** E_1 80-85% maxHR, E_2 max sprints **Duration:** E_1 20 min, E_2 8 - 16 min **Length:** 8 wks **Type:** E_1 continuous cycling, E_2 interval running	E_1	1.30	1.43	10.0	45.4	48.7	7.3 *
				E_2	1.54	1.67	8.4	48.3	50.3	4.1 *
				C	1.49	1.46	-2.0	44.9	43.8	-2.4
Welsman *et al.* (1997)†	2 groups E_1 n = 18 G, 10.1 y E_2 n = 17 G, 10.2 y	n = 16 G, 10.2 y	**Frequency:** 3 days/wk **Intensity:** E_1 80% maxHR, E_2 75 - 80% max HR **Duration:** E_1 20 min, E_2 20-25 min, E_2 8 - 16 min **Length:** 8 wks **Type:** E_1 continuous cycling, E_2 aerobics & circuit training	E_1	1.76	1.79	1.7	51.8	52.2	0.7 NS
				E_2	1.58	1.61	1.9	47.0	47.8	1.7 NS
				C	1.72	1.72	0.0	46.2	45.9	-0.6

B, boys; G, girls; AT, anaerobic threshold; HR, heart rate; † maturity assessed; * indicates significantly different from pretraining value at $P < 0.05$; NS indicates not significantly different from pretraining value at $P < 0.05$.

Table 1. (Continued) Exercise training and peak VO_2: studies with participants under 11 years of age

	Participants		Training protocol		Peak VO_2 ($L.min^{-1}$)			Peak VO_2 ($mL.kg^{-1}{\cdot}min^{-1}$)		
Study	Experimenta (E)l	Control (C)			Pre	Post	Change(%)	Pre	Post	Change(%)
Tolfrey *et al.* (1998)†	*n* = 12 B,	*n* = 10 B,	**Frequency** 3 days/wk	EB	1.60	1.66	3.8	46.6	47.2	1.3 NS
	10.6 y	10.3 y	**Intensity** 80% max HR; **Duration** 30 min,	EG	1.36	1.54	13.2	39.3	42.4	7.9 NS
	n = 14 G,	*n* = 9 G,	**Length** 12 wks	CB	1.62	1.65	1.9	50.7	50.3	-0.1
	10.6 y	10.5 y	**Type** Continuous cycling	CG	1.52	1.52	0.0	44.7	43.0	-3.8
Williams *et al.* (2000)†	2 groups									
	E_1 *n* = 13 B,	*n* = 14 B,	**Frequency** 3 **days/wk**	E_1	1.80	1.93	7.2	54.7	57.5	5.1 NS
	10.1 y	10.1 y	**Intensity** E_1 80 - 85% max HR [1] **,** E_2 max sprints	E_2	1.84	1.91	3.8	54.8	56.2	2.6 NS
	E_2 *n* = 12 B,		**Duration** E_1 20 min, E_2 6 - 8 min; **Length** 8 **wks**							
	10.1 y		**Type** E_1 continuous cycling, E_2 interval running	C	1.92	1.97	2.6	56.4	56.7	0.5
Mandigout *et al.* (2001)†	*n* = 18 B,	*n* = 28 B,	**Frequency** 3 **days/wk**; **Intensity** **Boys:** 75 -80% max HR continuous ,	EB	1.70	1.84	8.2	47.2	49.2	4.2 *
	10.7 y	10.5 y	Girls: 90% max HR interval; **Duration** Boys-15 - 20 min continuous,	EG	1.30	1.57	20.7	38.6	41.9	8.5 *
	n = 17 G,	*n* = 22 G,	Girls-60 - 90 min interval; **Length** 13 **wks**	CB	1.60	1.70	6.2	46.1	45.5	-1.3
	10.5 y	10.5 y	**Type** Boys-Continuous, Girls-Interval running aerobic activities	CG	1.40	1.50	7.4	39.6	39.5	0.2
Baquet *et al.* (2002)†	*n* = 13 B	*n* = 10 B,	**Frequency** 2 **days/wk**	E	1.54	1.68	9.1	43.9	47.5	8.2 *
	n = 20 G	9.0 y	**Intensity** 80 - 95% max HR; **Duration:** 30 min,							
	9.5 y		**Length** 7 **wks**; **Type** interval running	C	1.62	1.62	0.0	46.2	45.3	-1.9
	8.5 y									
Obert *et al.* (2003)	*n* = 9 B,	*n* = 9 B,	**Frequency** 3 **days/wk**; **Intensity** **Boys**-80% max HR continuous,	EB	_	_	_	44.1	50.9	15.4 *
	10.5 y	10.7 y	**Girls**- 90% max HR interval; **Duration** 60 min	EG	_	_	_	40.9	44.2	8.1 *
	n = 10 G,	*n* = 7 G,	**Length** 13 **wks**; **Type** Boys- continuous running	CB	_	_	_	51.5	50.3	-2.3
	10.4 y	10.7 y	Girls-interval running	CG	_	_	_	42.4	42.6	0.5

B, boys; G, girls; AT, anaerobic threshold; HR, heart rate; † maturity assessed; * indicates significantly different from pretraining value at $P < 0.05$; NS indicates not significantly different from pretraining value at $P < 0.05$.

There is therefore no evidence to indicate a greater effect of training on the peak VO_2 of those 11 years and above than those under 11 years of age. Similarly, of the eight studies which verified the prepubertal status of participants, five (63%) showed a significant increase in peak VO_2 and three reported no significant change. Therefore, despite suggestions of a "maturation threshold" *(Gilliam and Freedson, 1980)* or a "critical or trigger point" *(Katch, 1983)* underpinning trainability, the influence of age and maturation on increasing the peak VO_2 of 8-18 year-olds through training remains to be proven.

The Effect of Sex on Responses to Training

The majority of exercise training studies have recruited boys as participants and others have combined the data of boys and girls during analysis. Consequently, it is difficult to draw any conclusions about the effect of sex on responses to training from the studies presented in this review. Those which have compared the responses of boys and girls have concluded that the increase in peak VO_2 is of the same order in both sexes once initial peak VO_2 values have been taken into account *(Rowland, 1985; Tolfrey et al., 1998; Mandigout et al., 2001)*. Very few studies have addressed the issue of sex differences in response to training and further research is necessary.

Table 2. Exercise training and peak VO_2: studies with participants 11 years of age and above

Study	Participants: Experimenta (E)l	Participants: Control (C)	Training protocol		Peak VO_2 ($L.min^{-1}$) Pre	Post	Change(%)	Peak VO_2 ($mL.kg^{-1}{\cdot}min^{-1}$) Pre	Post	Change(%)
Massicotte & Macnab(1974)	3 groups *n* = 9 B in each 12.5 y	*n* = 9 B 12.5 y	**Frequency:** 3 **days/wk** **Intensity:** E_1 HR at 170 - 180 beats·min^{-1} E_2 HR at 150 - 160 beats·min^{-1} E_3 HR at 130 - 140 beats·min^{-1} **Duration:** 12 min, **Length:** 6 **wks** **Type:** Continuous cycling	E_1	2.00	2.30	15.0	46.7	51.8	10.8 *
				E_2	1.80	1.90	5.6	47.4	48.0	1.3 NS
				E_3	1.70	1.80	5.9	46.6	48.2	3.4 NS
				C	2.00	1.90	-5.0	45.7	44.2	-3.3
Stewart & Gutin (1976)	*n* = 13 B 10 - 12 y	*n* = 11 B, 10 - 12 y	**Frequency:** 4 **days/wk** **Intensity:** 90% of max HR **Duration:** 25 min, **Length:** 8 **wks** **Type:** interval running	E	_	_	_	49.8	49.5	-0.6 NS
				C	_	_	_	48.4	49.2	1.7
Burkett *et al.* (1985)	*n* = 10 G 15.6 y	*n* = 9 G, 15.6 y	**Frequency:** 5 **days/wk** **Intensity:** 70% of max HR continuous 90% of max HR interval **Duration:** started at 9.7 km·wk^{-1} up to32.2 km·wk, **Length:** 20 **wks** **Type:** continuous & interval running	E	_	_	_	45.1	49.4	9.3 *
				C	_	_	_	43.2	43.2	0.0
Mahon & Vaccaro (1989)	*n* = 8 B 12.4 y	*n* = 8 B, 12.3 y	**Frequency:** 4 **days/wk** **Intensity**70 - 80% max HR continuous 90 - 100% peak VO2, 135% HR at VT interval **Duration:** 20 - 30 min continuous 100 - 800 m (from 1.5 - 2.5 km) interval **Length:** 8 **wks** **Type:** Continuous & interval running	E	1.87	2.04	9.1	45.9	49.4	7.6 *
				C	1.77	1.84	4.0	45.4	45.9	1.1
Rowland & Boyajian (1995) †	*n* = 13 B, *n* = 24 G, 10.9 - 12.8 y	*n* = 13 B, *n* = 24 G, 10.9 - 12.8 y	**Frequency:** 3 **days/wk** **Intensity:** HR at 153 - 184 beats·min^{-1} **Duration:** 20 - 30 min **Length:** 12 **wks** **Type:** Aerobic circuit training distance running/walking games, basketball	E	2.02	2.24	10.9	44.7	47.6	6.5 *
				C	1.96	2.02	0.1	44.3	44.7	0.9
Rowland *et al.* (1996) †	*n* = 11 B, *n* = 20 G, 11.8 y	*n* = 11 B, *n* = 20 G, 11.8 y	**Frequency:** 3 **days/wk** **Intensity:** 87.5% max HR **Duration:** 30 min **Length:** 13 **wks** **Type:** aerobic dance, step aerobics, distance running, circuit activities	EB	2.15	2.29	6.5	45.4	48.2	6.1 NS
				EG	1.81	1.97	8.8	43.9	46.1	5.0 NS
				CB	2.08	2.15	3.4	45.3	45.4	0.2
				CG	1.46	1.81	24.0	43.7	43.9	0.4
Stoedefalke *et al.* (2000) †	*n* = 20 G 13.6 y	*n* = 18 G, 13.7 y	**Frequency** : 3 **days/wk** **Intensity:** : 75 - 85% max HR **Duration:** : 20 min **Length:** : 20 **wks** **Type** : treadmill running, cycle & rowing ergometry, stair stepping, aerobic dance	E	2.25	2.32	3.1 NS	_	_	_
				C	2.39	2.45	2.5	_	_	_

B, boys; G, girls; VT, ventilatory threshold; HR, heart rate; † maturity assessed; * indicates significantly different from pretraining value at $P < 0.05$; NS indicates not significantly different from pretraining value at $P < 0.05$.

Exercise prescription

Training programmes to improve cardiorespiratory fitness depend upon mode, frequency, duration and intensity of exercise and programme length. Each of these elements is discussed in the following sections and the studies summarised in Tables 1 and 2 were examined in detail in order to develop appropriate training guidelines.

Mode

A variety of exercise modes have been used in training studies undertaken with young people. Studies involving continuous exercise *(Massicotte and Macnab, 1974; Lussier and Buskirk, 1977; McManus et al., 1997)*, interval training *(Savage et al., 1986; McManus et al., 1997; Baquet et al., 2002)* and a mix of the two *(Burkett et al., 1985; Mahon and Vaccaro, 1989; Mandigout, et al., 2001; Obert et al., 2003)* have resulted in significant increases in peak VO_2. Similarly, both cycling and running training have produced increases in peak VO_2. It can be concluded that, exercise using large muscle groups, regardless of mode, has the potential to increase peak VO_2. However, studies incorporating both interval and continuous exercise appear to have been the most successful, possibly because the variation retained the participants' interest and attention and facilitated sessions of longer duration. Resistance exercise has also been observed to significantly increase peak VO_2 in two studies following 4 *(Docherty et al., 1987)* and 14 *(Weltman et al., 1986)* weeks of training.

Frequency and Duration

With two exceptions the frequency of training in all studies was 3 to 4 sessions per week. In a study performed by *Burkett and colleagues (1985)* 5 sessions per week were employed and only 2 sessions per week in a study conducted by *Baquet and colleagues (2002)*. Both of these studies demonstrated significant increases in peak VO_2 (i.e. 9.3% and 8.2% respectively).

The duration of sessions varied from 12 to 90 min with most studies in the range 20 to 40 min per session. Interestingly, the study employing a session duration of 12 min reported a significant increase in peak VO_2 only in the group training at high intensity *(Massicotte and Macnab, 1974)*. This indicates the potential importance of training volume (interaction between intensity and duration). In general, training sessions of 40 to 60 min have been the most successful in increasing peak VO_2.

Intensity

The intensity of exercise appears to be crucial and of the 9 studies which have used a training stimulus of 85% to 90% of maximum heart rate (HR max), 7 induced significant increases in peak VO_2. Two studies have specifically addressed training intensity. Savage and colleagues (1986) reported a significant increase in peak VO_2 in boys who trained at 85% of HR max but no increase in peak VO_2 in boys who trained at 70% of HR max. Similarly, Massicotte and Macnab (1974) compared boys who trained for 12 min, 3 times per week for 6 weeks at 66 to 72%, 75 to 80% or 88 to 93% of HR max. Only the group who trained at the highest intensity significantly improved peak VO_2. It is important to note that in both these studies the training groups were not matched for total exercise volume. The duration and frequency of the exercise sessions and the length of the training period were identical for each group. This would result in the boys in the higher intensity exercise groups expending more energy than those in the lower intensity exercise groups and consequently experiencing a greater exercise volume.

Programme Length

The length of training programmes ranged from 6 to 20 weeks but no clear inferences of length of programme on increase in peak VO_2 can be drawn from the available data. For example, *Stoedefalke and colleagues (2000)* trained postmenarcheal girls for 20 weeks without inducing an increase in peak VO_2 whereas *Massicotte and Macnab (1974)* demonstrated a 10.8% increase in peak VO_2 in boys after only 6 weeks of training.

A study conducted by *Obert and colleagues (1996)* is worthy of note because of the high frequency (10 per week) and long duration (60 to 90 min) of sessions and the programme length (52 weeks). The study is, however, limited by the small sample size (5 girls in the experimental group). To maintain consistency between training and assessment mode the pre-test and post-test assessments were carried out using a swim bench ergometer. This limits the ability to compare the results of this study with those that determined peak VO_2 using treadmill or cycle ergometer protocols. Nonetheless, the 29% increase in mass-related peak VO_2 seen as a result of training in the girls who participated in this study is striking. This study highlights the potential importance of long-term, specific training programmes. Given the inconsistency of significant improvements in peak VO_2 identified in studies lasting 7-8 weeks and the failure of some 12-week programmes to enhance peak VO_2 it seems prudent to recommend minimum programme duration of 12 weeks.

Conclusion

Current evidence does not support the view that prepubescent children cannot respond to exercise training. Detailed review of the literature suggests that if exercise volume is sufficient young people's peak VO_2 can be enhanced with training with typical increases of 6%. Few studies have examined sex differences in the trainability of young peoples' peak VO_2 but the available data do not indicate this to be a factor. From careful scrutiny of the studies summarised in Tables 1 and 2 appropriate guidelines for exercise training to improve young peoples' peak VO_2 were developed and are outlined in Table 3. These guidelines are recommended to improve cardiorespiratory (or aerobic) fitness as reflected by peak VO_2. Additional training would be necessary to improve other elements important for success in endurance performance.

Table 3. Exercise Prescription

Mode	Mixture of continuous exercise and interval training using large muscle groups
Frequency	Minimum 3 to 4 sessions per week
Duration	40 to 60 minutes
Intensity	85 to 90% of maximum heart rate
Programme length	Minimum length of 12 weeks

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