ORIGINAL ARTICLE

Heart rate responses of women aged 23–67 years during competitive orienteering

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Objectives: To compare the heart rate responses of women orienteers of different standards and to assess any relation between heart rate responses and age.
Methods: Eighteen competitive women orienteers completed the study. They were divided into two groups: eight national standard orienteers (ages 23–67 years); 10 club standard orienteers (ages 24–67 years). Each participant had her heart rate monitored during a race recognised by the British Orienteering Federation. Peak heart rate (HR_{PEAK}), mean heart rate (HR_{MEAN}), standard deviation of her heart rate during each orienteering race (HR_{SD}), and mean change in heart rate at each control point ($\Delta HR_{CONTROL}$) were identified. The data were analysed using analysis of covariance with age as a co-variate.
Results: National standard orienteers displayed a lower within orienteering race standard deviation in heart rate (6 (2) *v* 12 (2) beats/min, $p<0.001$) and a lower $\Delta HR_{CONTROL}$ (5 (1) *v* 17 (4) beats/min, $p<0.001$). The mean heart rate during competition was higher in the national standard group (170 (11) *v* 158 (11) beats/min, $p = 0.025$). The HR_{MEAN} for the national and club standard groups were 99 (8)% and 88 (9)% of their age predicted maximum heart rate (220–age) respectively. All orienteers aged >55 years (n = 4) recorded HR_{MEAN} greater than their age predicted maximum.
Conclusions: The heart rate responses indicate that national and club standard women orienteers of all ages participate in the sport at a vigorous intensity. The higher $\Delta HR_{CONTROL}$ of club standard orienteers is probably due to failing to plan ahead before arriving at the controls and this, coupled with slowing down to navigate or relocate when lost, produced a higher HR_{SD}.

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Previous research into the physiological demands of women's orienteering has primarily focused on elite level orienteers aged 21–35 years. The high level of fitness required at an elite level is reflected in the maximum aerobic power of women from the Danish (59.1 ml/kg/min)[1] and Norwegian (66.4 ml/kg/min)[2] national teams, and research into the physiological demands of the sport has recorded mean blood lactate levels of 3.4 mmol/l for women of the Norwegian national team during simulated orienteering races.[2]

Heart rate monitoring during competitive orienteering races has indicated mean heart rates of 172 beats/min for elite British Women[3] and 179 beats/min for members of the Norwegian women's national team.[2] According to Creagh and Reilly,[3] these values are similar to those observed during marathon running, but the variability in heart rate is much greater. For example, the standard deviation in heart rate for elite women within an orienteering race are generally reported to be in the region of 10 beats/min.[2 4]

Masters age categories for orienteering increase in five year increments from the age of 35 years, thereby providing an age related competitive structure at local, regional, national, and international orienteering races up to and including 90+ years. According to the International Orienteering Federation,[5] over one million people regularly participate in orienteering across 58 countries. At the 2001 British Orienteering Championships,[6] there were over 600 women competitors. Of these, 59% were aged over 35 years, with one of the most popular age classes being 50–54 years, in which there were 77 participants. However, despite the fact that orienteering is a popular competitive sport and recreational activity for women over 35 years of age in numerous countries throughout the world, relatively little is known about the demands of the sport and the physiology of those competing in the older age groups. Indeed there has been a relative paucity of research on older women athletes per se.

Therefore the aims of this study were to compare the heart rate responses of competitive women orienteers of different standards across a broad spectrum of ages and to assess whether the heart rate responses were related to age.

METHODS

The University College ethics committee approved the study.

Subjects and recruitment

Subjects were recruited through advertisements in local orienteering club newsletters, a national orienteering magazine, and leaflets distributed at British Orienteering Federation orienteering races. All subjects were regularly involved in competitive orienteering and had a minimum of four years experience, which ensured that they were familiar with the procedures and techniques of orienteering, and consequently were capable of providing valid data.

All subjects were informed that they were able to withdraw from the study at any time without any obligation. Before collection of the heart rate data, all subjects completed the following:

- general health questionnaire;
- consent form;
- questionnaire on current activity levels and general history of participation in physical activities;
- personal orienteering information sheet providing details of their orienteering history, standard of participation, and any specific achievements.

To assess the effects of standard on the subsequent heart rate data, the subjects were divided into two groups according to their standard at the time of data collection:

(1) National standard orienteers with more than 3500 national ranking points (pre-2001 British Orienteering Federation ranking system) and who had been ranked nationally

Table 1 Summary of participants' ages, orienteering experience, and race duration

	Age (years)	Age range (years)	Orienteering experience (years)	Orienteering race duration (min)
National group (n=8)	47 (14)	23–67	15 (9)	60 (14)
Club group (n=10)	40 (13)	24–67	11 (6)	77 (28)

Values are mean (SD).

in the top six for their age group within the previous year. All subjects in this group had also represented England or Scotland at Senior and/or Masters level and/or had finished in the top three for their age group at the British Orienteering Championships.

(2) Club standard orienteers with 2500–3500 national ranking points.

Collection of heart rate data

All the orienteering races used for data analysis in the study were recognised by the British Orienteering Federation and had a winning time in excess of 40 minutes. Orienteering races were therefore of a "classic" nature and did not include short or sprint orienteering races. Each participant was provided with a heart rate monitor (PE3000 or Sports Tester, Polar Electro Oy, Kempele, Finland) with which the participants were encouraged to familiarise themselves during training runs before using it during the orienteering race. Monitors were preset to record heart rate at 15 second intervals. During the orienteering races the subjects were requested to record their split times on arrival at each control (check point) by pressing the appropriate button on the monitor. After the race, the data were downloaded for analysis through the appropriate interface.

To assist with the analysis of heart rate data, each subject was requested to provide the following information after each orienteering race:

- copy of the race map with identified route and controls clearly marked;
- analysis sheet highlighting any important information about the race, such as any difficulties in locating particular controls or obstructive vegetation;
- time taken to complete the race (which was also available from published results lists).

This information was then used to identify any specific incidents that may have influenced the recorded heart rate data.

Analysis of the heart rate data

From the heart rate recordings, each of the following were identified and calculated. Using the criteria of Creagh *et al*,[4] data were omitted for the first four minutes of each race to allow the initial increase in heart rate to reach "normal" race intensity.

- Heart rate peak (HR_{PEAK}): the highest heart rate recorded during the orienteering race.
- Heart rate mean (HR_{MEAN}): the mean heart rate during the orienteering race (excluding the aforementioned first four minutes).
- Heart rate standard deviation (HR_{SD}): the standard deviation in heart rate within the orienteering race (excluding the aforementioned first four minutes).
- The mean change in heart rate at each control ($\Delta HR_{CONTROL}$): the change in heart rate occurring at a control was calculated as the difference between the highest heart rate recorded 15–30 seconds before reaching the control (as indicated from the split time recorded on the heart rate monitor) and the lowest heart rate recorded 45–60 seconds after leaving the control. A mean change in heart rate at controls was calculated for each competitor's race data.

A regression line was fitted to the heart rate profile of each race (time *v* heart rate recorded at 15 second intervals, excluding the aforementioned first four minutes) and assessed for positive or negative trends.[4]

Heart rate data for an orienteering race were to be rejected if they displayed uncharacteristic spikes or flat plateaus suggesting that the receiver had failed to record a true heart rate profile during the orienteering race. A participant's $\Delta HR_{CONTROL}$ was not calculated if they failed to record a split time for more than three of their controls.

Statistical analysis

Data were analysed using the Statistical Package for Social Sciences (SPSS version 10.0). Analysis of covariance was used to assess any differences in the responses of the groups (national standard *v* club standard), with age being the covariate. Regression analyses were used to determine any relations between each heart rate factor (HR_{PEAK}, HR_{MEAN}, and HR_{SD}) and the age of the participants. The data were checked for normality using Kolmogorov-Smirnov tests, and none violated normality. Values for HR_{PEAK} and HR_{MEAN} were compared with predicted maximal heart rate derived from the algorithm 220–age.[7]

To investigate any trend in heart rate within a race, regression analyses were used (time *v* heart rate recorded at 15 second intervals). Regression lines were classified as either positive or negative if $p<0.05$, and neutral if $p>0.05$. The frequency of positive, negative, and neutral regression lines were analysed using log-linear and χ^2 analyses (SPSS 10).

RESULTS

Eighteen women orienteers (eight national standard and 10 club standard) completed the study (table 1). Analysis of covariance with age as a covariate showed that HR_{MEAN} was

Table 2 Summary of heart rate data

Group	Peak heart rate (beats/min)	Mean heart rate (beats/min)	Within-race heart rate standard deviation (beats/min)	Average change in heart rate at controls (beats/min)
National group (n=8)	181 (11)	170 (11)	6 (2)	5 (1)
Club group (n=10)	179 (9)	158 (11)	12 (2)	17 (4)

Values are mean (SD).

Table 3 Regression analysis between heart rate responses (beats/min) and age (years) for national and club standard orienteers, and combined groups

Factor	Group	Heart rate correlation with age	r^2 Value	p Value
Peak heart rate (HR_{PEAK})	Combined	HR_{PEAK} = −0.256 age + 191	0.131	0.140
	National	HR_{PEAK} = −0.333 age + 197	0.193	0.276
	Club	HR_{PEAK} = −0.281 age + 190	0.166	0.243
Mean heart rate (HR_{MEAN})	Combined	HR_{MEAN} = −0.079 age + 166	0.008	0.732
	National	HR_{MEAN} = −0.412 age + 190	0.274	0.183
	Club	HR_{MEAN} = −0.020 age + 159	<0.001	0.950
Within race heart rate SD (HR_{SD})	Combined	HR_{SD} = −0.091 age + 13	0.137	0.131
	National	HR_{SD} = −0.015 age + 7	0.014	0.777
	Club	HR_{SD} = −0.059 age + 14	0.212	0.180
HR_{PEAK} as % of 220–age	Combined	% predicted HR_{max} = 0.468 age + 82	0.593	<0.001
HR_{MEAN} as % of 220–age	Combined	% predicted HR_{max} = 0.517 age + 71	0.492	<0.002

significantly higher in the national standard group ($F_{1,15}$ = 6.2, p = 0.025) (table 2). Regression analyses for HR_{MEAN} with age for the national, club, and combined groups data failed to find a significant relation (table 3). When HR_{MEAN} was expressed as a percentage of 220–age,[7] the women competed at 93 (10)% of their age predicted maximum heart rate. For the national standard group, this was 99 (8)%, and for the club standard group 88 (9)% of their age predicted maximum heart rate. A *t* test assuming unequal variances showed the groups to be statistically different (t = 2.64, df = 16, p = 0.018). When HR_{MEAN} was expressed as a percentage of predicted maximum heart rate and regressed with age, it was shown to increase by 5%/decade (table 3). All orienteers aged >55 years regardless of standard (n = 4) recorded HR_{MEAN} greater than their age predicted maximum heart rate of 220–age,[7] with this HR_{MEAN} being sustained for race durations of between 40 and 70 minutes.

Analysis of covariance with age as a covariate showed that HR_{SD} was significantly lower in the national standard group ($F_{1,15}$ = 41.2, p<0.001) (table 2). Regression analyses found no significant relation between age and HR_{SD} in either group or for their combined data (table 3). Likewise analysis of covariance with age as a covariate showed that $\Delta HR_{CONTROL}$ was significantly lower in the national standard group ($F_{1,8}$ = 41.5, p<0.001) (table 2) but was not related to age. Figure 1 clearly illustrates the differences in the heart rate profiles (HR_{SD} and HR_{MEAN}) of national and club standard women orienteers. Analysis of covariance with age as a covariate showed that HR_{PEAK} was not affected by the standard of the orienteer ($F_{1,15}$ = 1.3, p = 0.276) (table 2). Regression analysis using the combined data for the national and club standard groups indicated that HR_{PEAK} values showed a non-significant decline of 2.5 beats/min/decade with increasing age (table 3). When compared with their age predicted maximum of 220–age,[7] the HR_{PEAK} of national standard women orienteers was 102 (8)% of age predicted maximum heart rate. Of the 10 women orienteers over the age of 40 years (six of national standard and four of club standard), seven displayed peak heart rates above that predicted from 220–age. When the HR_{PEAK} of all the subjects was expressed as a percentage of predicted heart rate maximum and regressed with their age, there was a significant increase with age of 5%/decade (table 3). This indicated a growing discrepancy with increasing age between the HR_{PEAK} recorded during the orienteering race and that predicted from 220–age.

The linear regressions of heart rate profiles produced two positive (p<0.05), one negative (p<0.05), and five neutral (p>0.05) slopes in the national standard group, and two positive and eight neutral slopes in the club standard group.

DISCUSSION

The HR_{MEAN} calculated from the heart rate monitoring data suggests that experienced competitive women orienteers of all ages participate in the sport at what may be regarded as a strenuous intensity. They sustained relatively high heart rates for a prolonged duration. Indeed despite the inclusion of older orienteers (>40 years), the HR_{MEAN} of the national standard group (170 (11) beats/min) was similar to the 172 beats/min reported for young elite British women by Creagh and Reilly.[3]

The HR_{SD} of the national standard orienteers (6 (2) beats/min) was lower than that previously reported for younger women orienteers in national squads,[2 4] whereas that for the club standard orienteers was higher. Comments made on the analysis sheets suggest that the higher HR_{SD} of the club

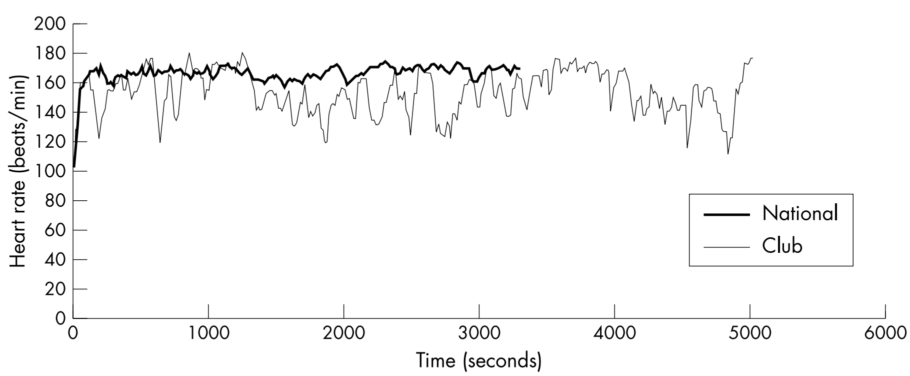

Figure 1 Heart rate profiles of a national standard (aged 41 years) and club standard (aged 37 years) orienteer.

standard orienteers was partly due to navigational errors that caused them to slow down and/or stop to relocate their position. A further factor contributing to the higher HR_{SD} was larger $\Delta HR_{CONTROL}$ of the club standard orienteers. Observations made at controls that were visible to the investigators suggested that the national standard orienteers had checked that the code of the control matched that on the list they carried while approaching the control and had planned their direction of exit from the control before reaching it. Consequently they minimised the amount of time spent at the control and resumed running immediately. Conversely, club standard orienteers were often observed to pause and check their control code after they had arrived at the control. They then exited from the control reading their map at a walking pace before starting to run again. This appeared to be due to their failure to plan their route to the next control, including their immediate exit from the one that they were at, before arriving at it. They may therefore be deemed to have wasted time at the control. The difference between the two groups is perhaps exemplified by paraphrasing a quote from a British Champion who said that "top orienteers pass through the controls which are on their route around the course, whereas club standard orienteers use the controls as beginning and end points to a navigational leg".

For the club standard group, fluctuations in running intensity caused by navigational difficulties (which were reported on the analysis forms) and the greater mean decrease in heart rate at controls is likely to have contributed to their lower HR_{MEAN}. Such fluctuations and variations may also explain why the regression of HR_{MEAN} with age was not significant.

The findings of this study indicate orienteering to be a physically demanding activity for both club and national standard women across the age range 23–67 years. Competitors displayed relatively high heart rate responses (HR_{PEAK} and HR_{MEAN}) during orienteering races. In older women orienteers of both national and club standard, heart rate algorithms such as 220–age appear to underestimate the heart rate responses of these "athletic" women and would therefore appear to be inappropriate for these groups. This is despite the fact that they were not specifically trying to attain an HR_{PEAK} and therefore their true maximum heart rate may be even greater.

The finding of HR_{MEAN} values greater than that predicted from the algorithm 220–age agrees with the results of Bird *et al*,[8] who suggested that women orienteers aged >45 years spent a considerable proportion of a competitive orienteering race with a heart rate higher than would be predicted from commonly applied algorithms such as 220–age for maximum heart rate.[7]

Take home message

Although many aspects of this paper are descriptive, they provide an original insight into the heart rate responses of older women athletes who are an under-researched group. During competitive orienteering, many of the women sustained heart rates that were above what may have been expected if age related heart rate algorithms were applied. The intensity of the exercise could be described as strenuous, with differences between national and club standard competitors being evident in the form of greater fluctuations in heart rate in the club standard group, probably caused by less competent navigation and failing to plan ahead.

Likewise, the mixture of neutral, positive, and negative heart rate profiles also agrees with the work of Creagh *et al*,[4] who indicated that, unlike cross country running races in which a consistent rise in heart rate was observed within a race, heart rate responses during orienteering races were less consistent and were likely to reflect the technical difficulty of the course as well as its topography.

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