

Karolinska Institutet, Department of Medicine, Cardiology Unit,  
Karolinska University Hospital, Stockholm, Sweden

# Cardiovascular assessment in middle-aged male long distance runners

AKADEMISK AVHANDLING

som för avläggande av medicine doktorsexamen vid Karolinska Institutet  
offentligen försvaras på engelska språket i Skandiasalen (Astrid Lindgrens  
Barnsjukhus, plan 1), Karolinska Universitetssjukhuset i Solna,  
fredagen den 14 december 2012 klockan 13.00

av

Philip Aagaard



**Karolinska  
Institutet**

## **Huvudhandledare**

Docent Frieder Braunschweig  
Institutionen för Medicin, Solna  
Karolinska Institutet

## **Bihandledare**

Professor Lennart Bergfeldt  
Avd för molekylär och klinisk medicin  
Sahlgrenska Akademien  
Göteborgs Universitet

Med. Dr. Anders Sahlén  
Institutionen för Medicin, Huddinge  
Karolinska Institutet

## **Fakultetsopponent**

Professor Hein Heidebuchel  
University of Leuven  
Leuven, Belgium

## **Betygsnämnd**

Professor Mats Börjesson  
Gymnastik- och idrottshögskolan  
Stockholm

Professor Carina Blomström-Lundqvist  
Institutionen för medicinska vetenskaper  
Uppsala Universitet

Docent Tomas Jernberg  
Institutionen för Medicin, Huddinge  
Karolinska Institutet

# Cardiovascular assessment in middle-aged male long distance runners

Philip Aagaard

Karolinska Institutet, Department of Cardiology,  
Karolinska University Hospital, Stockholm, Sweden

---

## Abstract

Endurance events such as long distance running races are increasing in popularity and convey multiple health benefits. However, such exercise forms also represent a major challenge to human cardiovascular physiology and are associated with a momentarily increased risk for adverse cardiac events. Using the world's largest cross-country running race *Lidingöloppet* as a model of endurance events, this thesis aims to: 1) investigate male and female participation and performance trends 2) detail the cardiovascular findings of a comprehensive cardiovascular preparticipation evaluation in novice male race participants aged 45 years and older 3) study the impact of race participation on cardiac autonomic tone and 4) assess features of cardiovascular function and vectorcardiography (VCG), and their response to endurance exercise in individuals with early repolarisation (ER).

**Study I,** Participation and performance trends were investigated in >120,000 runners partaking in the *Lidingöloppet* between 1993 and 2007. In a subgroup of 249 middle-aged males, the association between the cardiac biomarker NT-proBNP and runtime was also studied. Participation increased over the study period, particularly in females and older males, while participants' fitness deteriorated, as measured by an average increase in runtime of  $21 \pm 31$  min. Longer runtimes were independently associated with higher levels of NT-proBNP.

**Study II,** A preparticipation cardiovascular exam was performed in 153 middle-aged male first-time *Lidingöloppet* race participants. Runners were assessed by medical history and physical exam, 12-lead ECG, echocardiography, and blood tests. 9 % of runners required further diagnostic work-up and 2 % were discouraged from race participation due to cardiac abnormalities that could increase their risk of exercise-related cardiac events.

**Study III,** Heart rate (HR) and heart rate variability (HRV) was continuously measured from 48 hours before until 96 hours after a *Lidingöloppet* 30km race. Compared to pre-race values, HR was elevated during the night after the race while HRV remained depressed for 64 [51 - 96] hours after the race. A reduced HR recovery and a greater fall in HRV post race were associated with higher levels of high-sensitivity troponin T (hsTnT).

**Study IV,** The prevalence and associated cardiac features of ER, characterized by ST-segment elevation (STE) and/or J-waves, was investigated in 153 middle-aged males registered for first-time participation in the *Lidingöloppet* 10, 15 or 30km race. ER was present in 40 % and generally associated with features of better cardiovascular fitness. The cardiovascular effects of participating in the 30km race (n= 94) were also assessed after the race; runners with J-waves, but not with STE alone, showed changes of repolarisation parameters usually considered unfavourable (e.g. prolonged T peak-to-end (Tpe) and QTc).

**Conclusion** This thesis demonstrated that increased participation in a long distance running event (*Lidingöloppet*) was paralleled by deteriorating runtimes. In middle-aged men, longer runtimes were associated with higher levels of NT-proBNP. These findings may raise concern regarding the fitness and cardiovascular health of some of today's race participants. A comprehensive preparticipation evaluation identified 9 % of first-time runners needing additional work-up and 2% who were ultimately discouraged from participating, suggesting that such a protocol is useful to identify individuals requiring further testing prior to vigorous exercise. After the race there was a prolonged depression of HRV. The magnitude and duration of HRV depression correlated with higher levels of hsTnT, suggesting that the degree of troponin (Tn) increase after strenuous exercise may reflect the level of exercise-induced cardiovascular stress. ER was generally associated with a benign cardiovascular profile, although subjects with J-waves showed post-race changes in some parameters of ventricular repolarisation that are usually associated with increased arrhythmia propensity. More research into the mechanisms and potential preventive measures of adverse exercise related effects on cardiac function is warranted.

**Key words:** early repolarisation, exercise, heart rate variability, middle-age, NT-proBNP, screening, troponin, vectorcardiography

ISBN 978-91-7457-985-7