The Effects of High Intensity Interval Training on Cardiovascular Fitness Outcomes in Children and Adolescents: A Systematic Review and Meta-Analysis

Joseph Schenkel, Susan Bock, Spencer E Boyle, Caroline Dodd-Reynolds

Citation:
Joseph Schenkel, Caroline Dodd-Reynolds, Susan Bock, Spencer Boyle. The Effects of High Intensity Interval Training on Cardiovascular Fitness Outcomes in Children and Adolescents: A Systematic Review and Meta-Analysis. PROSPERO 2015

Condition or domain being studied:
Increasing cardiovascular fitness has been shown to aid in the prevention of metabolic and coronary disease, as well as improve performance, both physical and cognitive (Laukkanen et al., 2001; Aberg et al., 2009). From a preventive standpoint, improvements in physical fitness have been correlated with reductions in relative risk for a number of diseases and conditions. Moreover, this effect is graded, meaning that even small changes to a person's physical fitness may be beneficial (Warburton, Whitney Nicole and Bredin, 2006). Increasing both physical activity and physical fitness has also been shown to improve cognitive function, which may be particularly beneficial for the academic performance of children and adolescents. Acute bouts of moderate-to-vigorous physical activity, for example, appear to briefly bolster certain elements of cognitive performance, such as reaction time, working memory, attention, and on-task behaviour (Hogervorst et al., 1996; Hogan, Mata and Carstensen, 2013; Khol and Cook, 2013). These effects are also observable over the long term, as active, healthy children tend to perform better academically (Khol and Cook, 2013).

Despite the advantages of improving cardiovascular fitness through increased physical activity, many children and adolescents are failing to meet their daily-recommended levels (Hallal et al., 2012). Though there are many factors influencing physical activity, lack of time has been one of the most frequently cited barriers (Godin et al., 1994). High Intensity Interval Training may be defined as any type of exercise or training program involving cycling periods of high intensity physical activity, typically between 85-90% of maximal heart rate, with periods of relative rest or inactivity repeated over several cycles (Weston et al., 2014). Previous meta-analysis of 10 HIIT studies conducted in adult patients has indicated that these protocols may be more effective at increasing cardiorespiratory fitness and cardiovascular fitness (for example VO_{2max}), when compared with more traditional Moderate Intensity Continuous Training (MICT), eliciting similar benefits using substantially less time per session (Weston, Wisloff, and Coombes, 2013). Additionally, these types of protocols have been shown to elicit positive changes to cardiovascular fitness in as little as two weeks (Baker et al., 2014).

Despite the positive prospects for HIIT interventions, there is still much that remains unknown. In children and adolescents, it is unknown whether different HIIT intervention durations, session lengths, high intensity interval lengths, and exercise modes confer different changes in cardiovascular fitness and body composition. Additionally, the lack of longitudinal research raises questions regarding how sustainable HIIT may be in the long-term. Finally, though HIIT has been shown to improve cardiovascular fitness, it is unclear if these protocols may improve other elements of fitness such as speed and strength. The purpose of this review is to address some of these questions.
Review questions:
1. Which High Intensity Interval Training interventions (HIIT) are effective at eliciting positive changes to cardiovascular fitness in children and adolescents (5-17), particularly in regard to elements of duration, including overall intervention duration, total exercise time, and high intensity interval length?
2. Do different work-to-rest ratios elicit differential effects for cardiovascular fitness?
3. Is there a minimum amount of HIIT required to elicit improvements to cardiovascular fitness within this age range?
4. Do different exercise modalities affect the outcomes of the HIIT intervention?

Search strategy:
The Cochrane Library (Cochrane Database of Systematic Reviews, Cochrane Central Register of Controlled Trials (CENTRAL) Cochrane Methodology Register), Web of Knowledge, PubMed, ScienceDirect.
Age Range: 5-17 years
Date of Publication: Limited to publications up to January 31, 2016.
Language Limits: English

Types of studies to be included:
This review will include randomized control trials, experimental designs, quasi-experimental designs, and crossover studies using HIIT as one of the intervention strategies.

Participants/population:
Children and adolescents between the ages of 5 and 17.

Intervention(s), exposure(s):
Currently, no standard definition exists for what constitutes a HIIT protocol, so no restrictions will be placed on exercise type, total session time, high intensity interval time, or work-to-rest ratio. Intervention duration, however, must be at least four sessions, or approximately twice a week for a minimum two weeks. Though recent papers have proposed certain standards for what constitutes the high-intensity, such as participants achieving a minimum of 80% pre-tested peak heart rate, or setting the work intensity to greater than or equal to 100% of pre-tested VO₂max, these will be ignored due their lack of practicality in the field-based setting, which may cause the omission of relevant papers (Weston, Wisloff and Coombes 2013, Weston et al 2014). Additionally, although another systematic review conducted in adults required work-to-rest ratios of less than one, this will not be the case in this review, as one of the goals is to determine if different work-to-rest ratios elicit different effects (Weston et al 2014).

Studies will be included if they report:
-Human participants aged between 5 and 17 years
-At least one proxy measure of cardiovascular fitness, including field-based measures, such as the Multistage Fitness Test, or laboratory-based measures, such as VO₂peak VO₂max, taken pre- and post-intervention.
-Specific descriptions of the intervention design, including type of exercise, high intensity interval duration, rest period duration, and total number of repeated cycles.
-Description of the participants previous training experience level (if any), and/or fitness level
Comparator(s)/control:
Control groups will be those not exposed to any additional exercise or interventions outside of their normal daily activities. Comparators are likely to include groups that undergo some form of MICT intervention.

Outcomes:
Primary outcomes
Measures of cardiovascular fitness, including VO peak (or VO2max) using field-based measures, and/or laboratory-based measures of VO peak (or VO2max), where applicable.

Secondary outcomes
1. Anthropometric measures including participant mass (kg), body mass index (kg/m²), waist circumference (cm), and body fat percentage.
2. Anaerobic performance-related measures, such as sprint times at various distances, and jump height.
3. Measures of perceived exertion in HIIT and MICT
4. Safety measures of HIIT and MICT, such as number of reported injuries during the interventions

Data extraction:
The research team will use the electronic bibliographic databases: Web of Science (science and social science citation index), Pubmed, Science Direct, and The Cochrane Library (Cochrane Database of Systematic Reviews, Cochrane Central Register of Controlled Trials (CENTRAL) Cochrane Methodology Register) for the search. A two-field search strategy will be used in each database. The first field will search for studies involved with HIIT interventions and include the terms "High Intensity Interval Training" OR "High Intensity Intermittent Exercise" OR "High Intensity Interval Exercise" OR "Sprint Interval Training" OR "Intermittent Training." The second tier will be meant to sort studies based on the target age range of 5-17 years and include the terms "Children" OR "Adolescents" OR "Teenage" OR "School-Aged" OR Prepubertal OR "Prepubescent."

The research team will independently conduct searches based on the strategy outlined above. The primary reviewer and two members of the research team will screen the titles and abstracts of the retrieved records to determine if they meet the inclusion criteria. A third reviewer will be consulted in cases of disagreement. Kappa scores will be taken. A score of ≥ .4 will be considered acceptable to proceed with the review. Following the initial screening process, full texts will be retrieved for papers deemed to have met the inclusion criteria. A reference check of all included publications will then be conducted as a further precaution against any missed relevant studies. In the case of grey literature, or literature that has yet to be published, the research team will attempt to contact the authors of these works to acquire relevant information where possible.

A standardized data extraction tool designed prior to the review will be used for coding and data extraction. Coding will be completed independently by the primary reviewer and split between two other members of research team. Data extraction will include: study design, health of the participants prior to intervention, level of training prior to intervention, location of study, age of participants, total intervention duration, sessions per week, total session duration, work/rest ratios, duration of high intensity interval, indicator(s) of work interval intensity (where applicable), cardiovascular fitness outcomes, secondary outcomes, and perceived exertion measures.

Risk of bias (quality) assessment:
Risk of bias assessment for individual studies will be completed following the Cochrane Handbook (for RCTs/intervention studies). No studies will be excluded.

**Strategy of data synthesis:** Following data extraction, papers will be tested for heterogeneity using the methods described by the Cochrane Handbook, using the chi-squared statistic (Q) to determine the heterogeneity among studies, and the I-squared index to further test for the degree of heterogeneity. Meta-analysis will be conducted if and where possible.

**Analysis of subgroups/subsets:** Currently, the research team expects to divide the data into age groups, with the primary subdivisions between ages 5-11 and 12-17. Within each age group HIIT intervention strategies will be further categorized and compared based on exercise type, participant exercise experience/fitness level prior to intervention, total intervention duration, sessions per week, session duration, length of high intensity interval, work-to-rest ratio, and method of cardiovascular fitness measures.

**Dissemination plans:** The goal of the review is to help inform future HIIT-based intervention strategies. Once completed, the results will be submitted for publication in a peer-reviewed journal.

**Primary reviewer contact details for further information:**
Joseph Schenkel  
[j.a.schenkel@durham.ac.uk](mailto:j.a.schenkel@durham.ac.uk)  
School of Applied Social Sciences  
Durham University  
32 Old Elvet  
County Durham  
DH13HN

**Organization affiliation:**  
School of Applied Social Science, Durham University

**Review Team:**  
Dr. Caroline Dodd-Reynolds, School of Applied Social Sciences, Durham University  
Dr. Susan Bock, School of Applied Social Sciences, Durham University  
Dr. Spencer Boyle, Faculty of Health and Life Sciences, Northumbria University

**Conflicts of interest:**  
No known conflicts of interests to declare

**Keywords:**  
High intensity interval training; HIIT; Children; Adolescents; Exercise Intervention

**Anticipated or actual start date:**  
11 January 2016

**Anticipated end date:**
30 April 2016

**Review Status:**
On-going

**Language:**
English

**Country:**
United Kingdom

**Stage of review at time of submission**

<table>
<thead>
<tr>
<th>Step</th>
<th>Started</th>
<th>Completed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preliminary Searches</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Piloting of Study Selection Process</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Formal Screening of Search Results Against Eligibility Criteria</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data Extraction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risk of Bias (Quality) Assessment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data Analysis</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
References


