Fakultet sporta i fizičkog vaspitanja u Novom Sadu Studenti: Dino Mujanović D4/21, Dzemil Dzamović D10/21

**SCHOOL-BASED EXERCISE PROGRAMS FOR PROMOTING CARDIORESPIRATORY FITNESS IN OVERWEIGHT AND OBESE CHILDREN AGED 6 TO 10: A SYSTEMATIC REVIEW**

**Abstract:** *The aim of this study was to conduct a systematic review of the school-based exercise programs for promoting cardiorespiratory fitness in overweight and obese children aged 6 to 10. Electronic databases (Web of Science and PubMed) were used as searching tools for collecting the adequate studies, published in the past 20 years. A total of 12 studies met the criteria for inclusion in this review, with a total of 2810 participants, both male and female. The results suggested that high intensity interval training, multidisciplinary weight reduction program, the intensity of maximal fat oxidation, exergaming, small-sided football, aerobic and moderate to vigorous physical activities were interventions for promoting cardiorespiratory fitness. Furthermore, long-lasting interventions caused greater improvement of cardiorespiratory fitness than a shorter intervention.*

**Key words:** *primary school, preschool children, maximal oxygen consumption, heart rate.*

# INTRODUCTION

Cardiorespiratory fitness (CRF) is one of the most important health components of physical fitness (Veijalainen et al., 2016), which is mainly expressed in maximal oxygen intake (VO2max) or in metabolic equivalents (MET) (Lee, Artero, Sui, & Blair, 2010). It is well documented that CRF in children is directly related to general health during childhood, and can reduce the risk of cardiovascular disease (CVD) later in life (Ortega et al., 2008; Ruiz et al., 2009; Ruiz et al., 2016). Also, it has been shown that there is a link between low CRF in childhood and early mortality in adulthoods (Sui, et al., 2007). Therefore, it is highly recommended to work on improving CRF already in childhood in order to reduce the consequences of CVD later in life and to prevent premature death (Cao, et al., 2020; Rodrigues, Perez, Carletti, Bissoli, & Abreu, 2007).

There is an increase of school interventions aiming to improve and promote CRF in early childhood (Jankowski, Niedzielska, Brzezinski, & Drabik, 2015; Martínez et al., 2016; Meng, Yucheng, Shu, & Yu, 2022; Larsen et al., 2018; Ye, Pope, Lee, &Gao, 2019). Castro-Piñero et al., (2017), state in their study that a 2 year school exercise program for improving CRF has the effect of reducing the incidence of CVD in overweight and obese children aged 6 to 10. They also concluded that the CRF should be a monitored system in order to prevent the potential occurrence of CVD. Regarding the program frequency, in order for overweight and obese children to have positive results, the CRF exercise program should be conducted 3 to 4 times a week for at least 6 weeks (Braaksma et al., 2018). Recently, high-intensity circuit training (HIIT) showed to be an effective exercise intervention that led to significant improvements and therefore could be included in regular classes (Engel, et al., 2019). Studies suggest that the HIIT method leads to a large improvement in CRF in children, and affects the parameters related to neuromuscular and aerobic performance (Bauer, Sperlich, Holmberg, & Engel, 2022). Also, Stanly & Dharuman (2020), state in their study that tai-chi, pilates and yoga have proven to be methods that greatly influence the improvement of CRF.

It is necessary to raise people’s awareness of how low CRF can lead to numerous consequences during life, and its improvement should begin in childhood. Therefore, improving CRF should be an integral part of physical education programs in all lower grades of primary schools. The aim of this work was to conduct a systematic review of the school-based exercise programs for promoting CRF in overweight and obese children aged 6 to 10.

# 2. METHOD

## 2.1  Literature identification

Studies were searched and analyzed in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines (De Morton, 2009). The following databases were searched to collect relevant literature for this study: PubMed, Web of Science. The following terms were used during the search: ((school-based OR school-program OR intervention OR preschool OR primary school OR elementary school) AND (cardio-respiratory fitness OR CRF OR cardio fitness OR VO2max OR maximal oxygen consumption OR heart rate)) AND (overweight OR obese) NOT disease. Child: 6-12 years filter was turned on. Studies are selected on the basis of titles, keywords, abstracts, but primarily on the basis of the content of the study published in its entirety.

Table 1 Search strategy to identify articles

|  |  |  |  |
| --- | --- | --- | --- |
| Search 1 | Search 2 | Search 3 | Filters |
| school-based  school program  Intervention  preschool primary school elementary school | cardio-respiratory fitness  CRF  cardio fitness  VO2max  maximal oxygen consumption heart rate | overweight  obese | child: 6-12 years |

The descriptive method was used for the analysis of the obtained data, and the possible inclusion in the study was done on the basis of titles and abstracts. After a detailed identification process, studies were considered relevant if they met the inclusion criteria. The study search, value assessment and data extraction were conducted by two authors (D.S. and S.M.), after that each author conducted cross-identification of studies, after which the study was included in further analysis or rejection.

## 2.2. Inclusion Criteria

For the study to be included in the final analysis, it had to meet the following criteria: The first criterion for taking the study into account was that its primary goal was related to the impact of the school exercise program on cardiorespiratory fitness in overweight and obese children aged 6 to 10. The reason for this selection criterion was the elimination of studies that included children who did not belong to this age, and studies whose aim was not the impact of the school exercise program on cardiorespiratory fitness were also excluded. The second criterion was that the children who participated in the studies overweight and obese. The third criterion was that the studies were published in the past 20 years. The fourth criterion was that the studies were published in English. The fifth criterion was that studies were  original research.

Figure 1 PRISMA flow diagram

Reports sought for retrieval

(n = 47)

Records screened

(n = 1324)

Records identified from\*:

Databases (n = 2)

Web of Science (n = 948)

PubMed (n = 503)

Registers (n = 1451)

Records removed *before screening*:

Duplicate records removed (n = 102 (204 detected)

Records marked as ineligible by automation tools (n = 25)

Records removed for other reasons (n = 0)

**Identification of studies via databases and registers**

**Identification**

Records excluded by human

(n = 1277)

Reports not retrieved

(n = 1)

Reports excluded:

Ineligible study design (n = 8)

Ineligible population (n = 21)

Ineligible intervention (n = 5)

Reports assessed for eligibility

(n = 46)

Studies included in review

(n = 12)

**Screening**

**Included**

## 2.3. Risk of Bias Assessment

Two independent authors (D.M. and R.M.) assessed the quality of the study and the possibility of including it in the final analysis. Blind reviewing was carried out by using “Rayyan” web-tool. In case of disagreement regarding the findings on the assessment of the risk of bias, the obtained data were assessed by a third reviewer (V.M.) who made the final decision.

# **RESULTS**

## Quality of the Studies

The study assessment scores were calculated using the total number of studies included in the quantitative synthesis and the points each research received on the PEDro scale (Maher). First criteria (eligibility criteria) is concerned for external validity and it is not counted for the final score.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Criterion | | | | | | | | | | | |
| Study | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | **∑** |
| Thivel et al. (2011) | Y | Y | Y | Y | N | N | N | Y | Y | Y | Y | 7 |
| Raseland et al. (2011) | Y | N | N |  | N | N | N | N | Y | Y | Y |  |
| Yin et al. (2012) | Y | Y | Y | Y | N | N | N | N | Y | Y | Y | 6 |
| Krustrup et al. (2014) | Y | Y | Y | Y | N | N | Y | Y | Y | Y | Y | 8 |
| Khan et al. (2014) | Y | Y | Y | Y | Y | N | N | Y | Y | Y | Y | 8 |
| Tan et al. (2015) | Y | Y | Y | Y | N | N | N | Y | Y | Y | Y | 7 |
| Martinez et al. (2016) | Y | Y | Y | Y | N | N | N | Y | Y | Y | Y | 7 |
| Leeuwen et al. (2018) | Y | N | N | N | N | N | N | Y | Y | N | Y | 3 |
| Ye et al. (2019) | Y | Y | Y | N | N | N | N | Y | N | Y | Y | 5 |
| Davis et al. (2019) | Y | Y | Y | Y | Y | N | N | Y | Y | Y | Y | 8 |
| Espinoza-Silva et al. (2019) | Y | N | N | Y | N | N | N | Y | Y | Y | Y | 5 |
| Leandro et al. (2021) | Y | Y | Y | Y | N | N | N | Y | Y | Y | Y | 7 |
| Martinez-Viscaiano et al. (2022) | Y | Y | Y | Y | Y | Y | Y | Y | N | Y | Y | 9 |

Legend: 1—eligibility criteria; 2—random allocation; 3—concealed allocation; 4—baseline comparability; 5—blind subject; 6—blind clinician; 7—blind assessor; 8—adequate follow-up; 9—intention-to-treat analysis; 10—between-group analysis; 11 —point estimates and variability; Y—criterion is satisfied; N—criterion is not satisfied; ∑—total awarded points.

## Selection and Characteristics of Studies

There were 1451 studies found after searching the electronic databases. One thousand three hundred and twenty-four studies remained after the removal of duplicates, systematic reviews and meta-analysis. A total of 42 studies were assessed for eligibility after 1277 studies were rejected due to certain inclusion requirements. Finally, remaining studies were screened and read in their entirety, after that, 12 studies were included in the final analysis.

*Table 2 Review of the studies.*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **First Author and Year of Publication** | **Sample of Participants** | | **PF** | **Type of intervention** | **Duration of intervention** | **Results** |
|  | **Number** | **Age** |  |  | **Months** |  |
| Thivel et al. (2011) | N – 457 | 6 - 10 | SRT | AL, 2/w | 6 | CRF↑ |
| Raseland et al. (2011) | N – 256  M – 125  F – 131 | 9 - 10 | VO2peak | Daily, MVPA | 24 | VO2peak ↑ |
| Yin et al. (2012) | N – 574 | 8.7 ± 0.5 | HR; ST | Daily, Kids4Fit | 36 | CRF↑ |
| Krustrup et al. (2014) | N – 51  M – 21  F - 30 | 9 -10 | LVPWD; resting HR; resting BP | SSF, 3x/w | 2.5 | CRF↑ |
| Khan et al. (2014) | N – 220  M – 117  F – 103 | 8 - 9 | Treadmill | Daily MVPA | 9 | CRF↑ |
| Tan et al. (2015) | M - 46 | 8 -10 | SRT | Daily, FATmax | 2.5 | CRF↑ |
| Martinez et al. (2016) | N – 94  M – 52  F - 42 | 7 - 9 | VO2max, EPOC | HIIT, 2x/week | 3 | VO2max↑; EPOC↑ |
| Leeuwen et al. (2018) | N – 154  M – 66  F – 88 | 8.5 ± 1.8 | SRT VO2max, BP | Kids4Fit, 2xweek;1xweek | 3 | SRT↑ |
| Ye et al. (2019) | N – 81  M – 42  F - 39 | 9.23 ± 0.62 | HMR | EXG, 1/week | 8 | / |
| Davis et al. (2019) | N – 75  M – 29  F – 46 | 9.5 - 9.8 | PWV, BP, VO2peak (treadmill) | Daily, ASAE | 8 | VO2peak↑ |
| Espinoza-Silva et al. (2019) | N – 274  M – 120  F – 154 | 7 - 9 | BP; 6MWT | HIIT, 2x/w | 7 | VO2max↑ |
| Martinez-Viscaiano et al. (2022) | N – 487  M – 233  F – 254 | 9.89 ± 0.71 | SRT; ALPHA fitness test battery | HIIT, 4x/w | 9 | CRF↑F |
| **Legend:** ↑ significant improvement; **N –** number of respondents; **G** – gender; **М** – male respondents; **F** – female respondents; **w** – week; **PF** – physical fitness test; **CRF –** cardiorespiratory fitness; **BP** – blood pressure; **KPR -** Kasch Pulse Recovery Test; **SSF** - small-sided football; **AL –** additional lessons; **PLT** – plyometric training; **HIIT** – high intensity interval training; **VO2max** – maximal oxygen consumption; **VO2peak**– peak oxygen uptake; **HR** – heart rate; **LVPWD** – left ventricular posterior wall diameter; **PWV -** Carotid-femoral pulse wave velocity; **BP** – blood pressure; **EPOC** – excess post-exercise oxygen consumption; **ST** – step test; **6MWT** - 6-minute walk test; **HMR –** half-mile run; **Kids4Fit** - multidisciplinary weight reduction program; **SRT** – shuttle run test; **MVPA** - moderate-to-vigorous intensity physical activity; **EXG** – exergaming; **ASAE** – after school aerobic exercise; **FATmax** - the intensity of maximal fat oxidation rate. | | | | | | |

Twelve studies met the inclusion criteria for inclusion in this review. The oldest study was published in 2011 (Thivel), and the most recent one is from 2022 (Martinez-Viscaiano, 2022). The total number of participants was 2810. The highest number of participants was 574 (Yin), and the lowest number of participant was 41 (Leandro). In almost all studies, the participants were both sexes. However, the participants were male in two studies (Leandro, Tan), while no study was done with females. The longest intervention (36 months) was by Yin, and the shortest interventions (2 and a half months) were by Krustrup and Tan. All studies aimed to improve CRF, and post-intervention CRF improvement was found in all studies except in one (Ye). The interventions most used in the studies were high intensity interval training (Espinoza-Silva, Martinez, 2016 Martinez-Viscaiano, 2022) and daily physical activity (Davis, Khan, Raseland, Tan, Yin).

# DISCUSSION

The current study aimed to conduct a systematic review of the school-based exercise programs for promoting CRF in overweight and obese children aged 6 to 10. CRF has the important role of children’s health status, which is why the school's physical education program should include exercises for promoting CRF in order to increase their aerobic capacity. According to the results of the studies, there are 10 school-based programs (shorter and longer) that have some extent affects the improvement of CRF in overweight and obese children aged 6 to 10. Consequently, interventions such as high intensity interval training, plyometric training, multidisciplinary weight reduction program (Kids4Fit), football and active video gaming have the influence of respiratory abilities of children and reduce the risk of CVD.

There is strong evidence that high intensity interval training (HIIT) can be feasible and powerful tool for improving CRF (Burgomaster, Gibala, Whyte, Bosman, Bogataj). The review of the literature shows that there are paper works which involve school-based program of HIIT training in younger categories 6 to 10, although it is widely used in older population (Chin, Jimenez-Garcia, 2022, Jimenez-Garcia, 2021, Riley, Berge). Martinez-Visciano, using HIIT training improved the girls’ CRF through one school year, on the other hand, Martinez et al., 2016 enhanced VO2max in overweight children in only three months conducting two HIIT trainings per week using high intensity intermitted exercises and sport activities such as: half-squats, sprints, jumps and horizontal shot puts. In addition, strategies with exercise machines such as bicycle and treadmill as well as basic motor skills (running, jumping, throwing) were used in high intensity program (Espinoza-Silva). It can be accepted that school-based HIIT training program lead to improvement of aerobic capacity of overweight and obese children.

After school aerobic exercises, moderate to vigorous physical activity (MVPA), multidisciplinary weight reduction program (Kids4Fit) and the intensity of maximal fat oxidation rate (FATmax) were school-based exercise programs for promoting CRF in overweight and obese children aged 6 to 10 (Davis, Tan, Khan, Raseland, Yin). It can be said that daily engagement in these physical activities has led to a great improvement in CRF and aerobic abilities of lower school age children. Furthermore, Leeuwen used Kids4Fit as an intervention to promote CRF, with the intervention being done twice a week for the first six weeks and only once a week for the last six weeks. In this study, a significant positive effect on CRF improvement was also found in overweight and obese children, but after the intervention, CRF abilities gradually declined. These findings would suggest that Kids4Fit was a good school-based intervention program for promoting CRF in children of lower school age, but it is necessary to do the intervention daily and for a longer period of time.

The regular classes of physical education are not enough in order to promote the children’s CRF. If two additional workouts are added that include exercises to improve coordination, strength, endurance, speed, and flexibility to regular classes, the improvement in CRF and heart rate in overweight and obese children can be greatly influenced (Thivel). Also, exergaming and small-sided football are two interesting and fun ways to realize additional classes of vigorous intensity. In addition to children’s enjoyment, they also regulate their aerobic abilities by using these interventions (Krustrup, Ye). It is necessary for the realization of children’s regular classes to be fun and playable in order improve their CRF and aerobic abilities.

The main limitation of this review was inadequate sample of participants of published studies. Furthermore, the aim of studies was not the improvement of CRF but other parameters of morphological and physiological characteristics.

# CONCLUSION

The results of this systematic review showed that there were interventions that led to improvement in CRF in overweight and obese children aged 6 to 10. Long-lasting interventions caused greater improvement of CRF than a shorter intervention. Our findings provide the evidence that school-based exercise programs greatly influence the CRF.

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