AALBORG UNIVERSITET

Titel: [Effects of age and sex on feasibility and acceptability of a 12-week community-based exercise intervention in children and adolescents with overweight or obesity.]
Semester: [4. semester, kandidat idræt]
Projektperiode: [1. februar 2022 - 1. juni 2022]
ECTS: [30]
Vejledere: [Ryan Godsk Larsen, Morten Bilde Simonsen & Charlotte Nørkjær Eggertsen]
Projektgruppe: [Hst-22-idr-10-101]

Jeppe Bech Pedersen

Oplag:	[1] stk.
Antal sider:	[39] sider
Appendiks:	[1] stk.

Aim: The present study investigated the feasibility and acceptability of a 12-week community-based high-intensity interval training (HIIT) intervention, with different modalities for children and adolescents with overweight or obesity. Additionally, the feasibility and acceptability were investigated in subgroups of sex (girls vs. boys) and age (children vs. adolescents).
Method: 63 participants were recruited to a 12-week community-based HIIT intervention with 36 training sessions. nine training sessions in week 2, 6, and 11 consisted of either ball games, CrossFit, and running where enjoyment and perceived exertion were collected, while heart rate, attendance rate, and dropouts were collected throughout all 36 training sessions.
Results: Ball games elicited less time in the high-intensity zone compared to CrossFit ($P = 0.010$) and running ($P = 0.025$). No differences were found in the subgroups sex (girls vs. boys) and age (children vs. adolescents). Ten dropouts were registered, and attendance rates were significantly different between children and adolescents in weeks 9-12 ($P = 0.032$). Furthermore, a significant decline in attendance rate was seen from weeks 1-4 to weeks 9-12 for girls ($P = 0.006$), boys ($P < 0.001$), children ($P = 0.011$), and adolescents ($P < 0.001$). Enjoyment of physical activity was high, but no significant difference was found. The perceived exertion was rated lower by adolescents in ball games compared to CrossFit ($P = 0.017$) and running ($P = 0.004$). Furthermore, when combined the participants perceived ball games less exhausting than CrossFit ($P = 0.002$) and running ($P = 0.003$).
Conclusion: It was not feasible to elicit 16 minutes in the high intensity zone. CrossFit and running seem favorable to elicit more time in the high-intensity zone compared to ball games, with no major differences between the subgroups of sex (girls vs. boys) and age (children vs. adolescents). Acceptability showed that the intervention was highly liked by all the participants, with a low dropout rate and a high attendance rate that declined over time.

Effects of age and sex on feasibility and acceptability of a 12-week community-based exercise intervention in children and adolescents with overweight or obesity.

Jeppe Bech Pedersen.
Sport Science. Aalborg University: Fredrik Bajers Vej 7, 9220 Aalborg Øst, Denmark.

Abstract

Aim: The present study investigated the feasibility and acceptability of a 12-week community-based high-intensity interval training (HIIT) intervention, with different modalities for children and adolescents with overweight or obesity. Additionally, the feasibility and acceptability were investigated in subgroups of sex (girls vs. boys) and age (children vs. adolescents).
Method: 63 participants were recruited to a 12-week community-based HIIT intervention with 36 training sessions. nine training sessions in week 2, 6, and 11 consisted of either ball games, CrossFit, and running where enjoyment and perceived exertion were collected, while heart rate, attendance rate, and dropouts were collected throughout all 36 training sessions.
Results: Ball games elicited less time in the high-intensity zone compared to CrossFit ($P = 0.010$) and running ($P = 0.025$). No differences were found in the subgroups sex (girls vs. boys) and age (children vs. adolescents). Ten dropouts were registered, and attendance rates were significantly different between children and adolescents in weeks 9-12 ($P = 0.032$). Furthermore, a significant decline in attendance rate was seen from weeks 1-4 to weeks 9.12 for girls ($P = 0.006$), boys ($P < 0.001$), children ($P = 0.011$), and adolescents ($P < 0.001$). Enjoyment of physical activity was high, but no significant difference was found. The perceived exertion was rated lower by adolescents in ball games compared to CrossFit ($P = 0.017$) and running ($P = 0.004$). Furthermore, when combined the participants perceived ball games less exhausting than CrossFit ($P = 0.002$) and running ($P = 0.003$).
Conclusion: It was not feasible to elicit 16 minutes in the high intensity zone. CrossFit and running seem favorable to elicit more time in the high-intensity zone compared to ball games, with no major differences between the subgroups of sex (girls vs. boys) and age (children vs. adolescents). Acceptability showed that the intervention was highly liked by all the participants, with a low dropout rate and a high attendance rate that declined over time.

Introduction

In Denmark from 2017-2020, 14% children from 6-7 years old and 19% adolescents from 14-15 years old were overweight or obese[1]. This constitutes a major problem among children and adolescents since overweight and obesity often follows into adulthood, with a higher risk of diseases such as type 2 diabetes, high blood pressure and cardiovascular diseases[2]. To prevent these risk factors in children and adolescents with overweight or obesity, multidisciplinary lifestyle interventions has been recommended by several cochrane reviews[3,4] and meta analysis[5,6]. Multidisciplinary lifestyle interventions typically include recommendations for diet, sleep and exercise[4]. A well established Multidisciplinary lifestyle intervention used in Denmark is the children's obesity clinic's treatment (TCOCT) intervention[7]. The TCOCT intervention has specified recommendations for diet, sleep, screen time, and physical activity[7,8]. The current physical activity recommendations in the TCOCT intervention include 60 minutes of moderate to vigorous daily exercise, with different sport activities such as cycling and swimming to choose between[7,8]. These recommendations align with the recommendations from the Danish Health Authority who also recommend 60 minutes of moderate to vigorous physical activity[9]. However, The World Health Organization showed that only 15 % of Danish 11, 13, and 15 year olds reach the recommended level of daily physical activity[10].

To increase the low level of physical activity in children and adolescents, barriers for physical activities need to be considered, especially when dealing with children and adolescents with overweight or obesity[11,12]. Alberga et. al (2013) mention; transport, lack of training with peers and monotonous training sessions as main barriers for physical activity in children and adolescents with overweight or obesity[11]. To further optimize the TCOCT intervention, relevant community-based exercise interventions with varying modality training sessions exclusively for children and adolescents with overweight or obesity needs to be established.

One training method that has been showing good results in children and adolescents with overweight or obesity is high-intensity interval training (HIIT). HIIT consists of periods with high-intensity exercise of ≥ 85 % maximum heart rate with short recovery periods of ≤ 70 % maximum heart rate[13]. It is stated in a relatively new meta review that HIIT training consisting of ≥ 2 minute intervals, ≥ 15 minutes

training, 2-3 times weekly ≥ 7 weeks, lead to the best health outcomes in children and adolescents with overweight or obesity[13]. These beneficial traits include improved maximal oxygen uptake[6,13], reduced body mass[13,14], reduced body fat[13,14], reduced systolic and diastolic blood pressure[13,14], and insulin sensitivity[13-15].

HIIT seems to be a good exercise intervention for children and adolescents with overweight or obesity. However, to implement this training in a community-based exercise intervention with varying training modalities further information about feasibility and acceptability is important. To examine this lack of information, the present study is part of a larger ongoing study including children and adolescents with overweight or obesity. The study has a 12-week community-based HIIT intervention with different training modalities incorporated consisting of ball games, CrossFit, and running. Tjønna et al. (2009) showed that it is feasible for overweight or obese adolescents to perform a three month HIIT intervention walking or running on a treadmill for 40 minutes with 4 x 4-minute HIIT intervals in a laboratory setting[16]. However, a gap between the litterature when going from laboratory settings to community-based health settings is still present when dealing with children and adolescents with overweight or obesity[17]. Hence it is important to investigate whether the children and adolescents with overweight or obesity are capable of sustaining the wanted exercise intensity. It is also important to investigate whether certain exercise modalities elicit a higher intensity without intensity monitoring in a community-based HIIT intervention, to ensure the beneficial health outcomes[13,14,18]. Acceptability of an exercise intervention is another important component to ensure a high attendance rate and low dropout rate throughout the intervention[12]. Key components to acceptability is the enjoyment and perceived exertion of the intervention which affect attendance rate during an exercise intervention[11,12,19]. A study by Herget et al. (2016) investigated the acceptability of a six months real-world HIIT intervention with running exercises for 60 minutes on overweight adolescents[20]. Herget et al. (2016) showed an overall good enjoyment of physical activity at 2.8 from 1 “liked the program very much” to 10 “did not like the program at all”[20]. But although the intervention was well liked, the attendance rate went from 75 % the first two months to 15 % the last three months. The present study aims to see if a 12-week community-based HIIT intervention with varying modalities consisting of ball games, CrossFit, and running seem more acceptable for the children and adolescents with overweight or obesity.

Additionally feasibility and acceptability of a community-based HIIT intervention with varying modalities may be experienced differently across sex and age[11,12]. Studies have shown that boys and girls have different motivational preferences according to physical activity[21,22]. Boys seem to be more motivated through better performance, competition, and physical contact in physical activity, whereas girls prefer gaining friendship and social interaction with peers in game-based activities[21-26]. Additionally, obese Adolescents often have lowered self-esteem as a consequense of lowered mobility which can make them nervous when performing physical activity[27,28]. The children, however, may not have developed the lowered self-esteem yet and thereby participate more actively in physical activity[27-30]. However it is to this study's knowledge not examined how a community-based HIIT intervention with varying modalities affects children and adolescents with overweight or obesity across sex (girls vs. boys) and age (children vs. adolescents) in terms of feasibility and acceptability.

The purpose of the present study is to investigate feasibility and acceptability with the use of pulse, enjoyment, perceived exertion, attendance rate and dropout rate of a 12-week community-based HIIT intervervention with training sessions consisting of ball games, CrossFit, and running on children and adolescents with overweight or obesity. Additionally subgroup differences in pulse, enjoyment, perceived exertion, and attendance rate will be investigated for girls and boys and children and adolescents.

Method

Participants

The participants were recruited from communal obesity clinics in North Jutland. 63 children (9-11 years) and adolescents (12-16 years) with overweight or obesity were included with a Body Mass Index above the 90th percentile for sex and age. 90-94th percentile was categorized as overweight and ≥ 95 percentile as obese[31]. The participants' demographic data are shown in Table 1.

Due to the explorative nature of the present study participants were not excluded for non-participation, only if they did not come to any of the training sessions from the beginning. Otherwise the participants were excluded if they had

physical limitations or diseases that prevented them from completing the study design, including diseases that impact the respiratory system, metabolism and heart. Ten participants were excluded due to no participation at all.

All the participants and their legal guardians gave written consent before the intervention started and the study was in compliance with the Declaration of Helsinki and the North Denmark Region Committee on Health Research Ethics.

Table 1: Demographic data of all the participants and the subgroups; boys, girls, children, and adolescents. All non-normal distributed data are presented as median (Q1-Q3), and normally distributed data is presented as mean ± SD.

	All	Boys	Girls	Children	Adolescents
N	53	33	20	18	35
Age (years)	12 (11-13)	12 ± 1.50	12 (11-13)	11 (10-11)	13 (12-13)
Height (m)	1.59 ± 0.09	1.60 ± 0.11	1.59 ± 0.08	1.51 ± 0.06	1.64 ± 0.08
Weight (kg)	74.59 ± 16.39	75.13 ± 16.34	73.71 ± 16.44	62.09 ± 12.29	81.02 ± 14.40
BMI (kg/m2)	28.84 ± 4.04	28.91 ± 3.94	28.73 ± 4.20	25.49 (23-31)	29.75 ± 3.30
Overweight	3	1	2	2	1
obese	50	32	18	16	34

Study design

The HIIT intervention group participated in a 12-week HIIT intervention with three HIIT training sessions each week, resulting in 36 training sessions during the intervention. All trainings took place in community-based settings at the childrens local school gymnastic hall. The teams included 5-10 children and adolescents with overweight or obesity. Week 2, 6, and 11 consisted of one ball games training, one CrossFit training, and one Running training, in a counterbalanced order. Every training in week 2, 6, and 11 ended with a questionnaire that included physical activity enjoyment scale (PACES) and ratings of perceived exertion. In weeks 1, 3-5, 7-10, and 12, the trainers had a free choice between the three modalities: ball games, CrossFit, and running, meaning they could conduct training including all three modalities, Figure 1. A.

Training

Sports science students and physiotherapist students were recruited to conduct all the training sessions during the intervention. Before the students conducted the training they had a short briefing of what the training should include. Additionally the students were told to encourage the children and adolescents with overweight or obesity during training.

Each training consisted of HIIT which started with a 10-minute warm-up period at 70 % maximal heart rate, accompanied by 4 x 4-minute intervals at 90-95 % maximal heart rate. The recovery between the intervals was a 3-minute period at 70% maximal heart rate. A 5-minute cool-down period ended the training at a total of 40 minutes, Figure 1. B[16]. During every training session the participants pulse was recorded with a chest belt (Suunto dual comfort belt) using a team system, but were not actively monitored by the trainers or children and adolescents. Additionally, The students were not told to use a specific motivational theory, but were encouraged to adjust the training sessions to what the children and adolescents with overweight or obesity liked and found enjoyable.

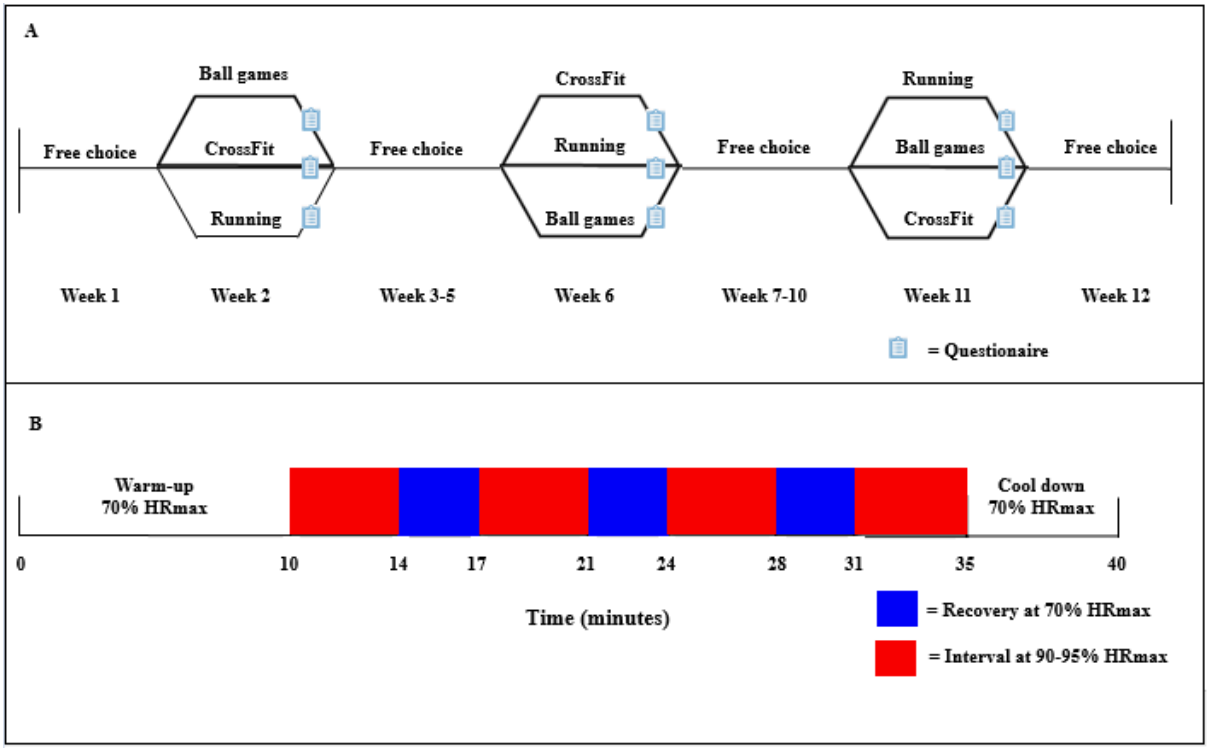


Figure 1. A: Illustration of the 12-week study design. Figure 1. B: Illustration of the High-intensity interval training (HIIT) used for all 3 training sessions each week.

Questionnaires

At the end of the three training sessions with ball games, CrossFit and running in week 2, 6, and 11, enjoyment of the physical activity was assessed using a modified PACES questionnaire validated on both children and adolescents[32,33]. The modified PACES questionnaire consists of 16 bipolar questions rating from one “disagree a lot” to five “agree a lot”[33]. To help the children and adolescents comprehend the scale each rating had matched facial expressions[32]. To calculate the final PACES score, questions 2, 3, 5, 7, 12, 13, and 16 are reversed and then an average of all 16 questions is calculated[33].

Additionally, a Borg category-Ratio-10 scale (CR-10) for ratings of perceived exertion was assessed at the end of each training in week 2, 6, and 11, which in previous studies has been validated for several activities in children and adolescents[34,35]. The Ratings of the perceived exertion scale range from zero “minimal perceived exertion” to 10 “maximal perceived exertion”, with five matching facial expressions added[35,36].

To further help the children and adolescents comprehend the questions, both the PACES questionnaire and ratings of perceived exertion were translated to their native language, Danish.

Data processing

To examine the participants time in each intensity zone during the training intervention their estimated maximum heart rate was calculated with the formula: 208 - (0.7 * age)[37]. A Suunto dual comfort belt was used to obtain the heart rate measurements during training sessions. For application, the belt was moistened and placed across the chest, if the belt could not obtain the participants heart rate the censor was placed on the back of the participant. The heart rate was transferred to a team manager software 2.3 powered by Suunto using a Suunto team pod with a wireless sensor network. Afterward the data was uploaded to Iqniter cardio training software 3.5 (2021, Aalborg, DK). After that the heart rate data was downloaded and divided into three intensity zones both in normalized (time in %) and absolute (time in minutes) data. The three intensity zones used in the present study were:

low-intensity zone (<60 % maximal heart rate), moderate-intensity zone (60-84 % maximal heart rate)[6], and high-intensity zone (≥85 % maximal heart rate)[13].

Statistical analyses

The mean heart rate data of each intensity zone from each ball games-, CrossFit-, and running training in week 2, 6, and 11 were divided into four subgroups: girls, boys, children, and adolescents. Each subgroup and the whole sample were analyzed for normality using the Shapiro-Wilk test and Q-Q plots. Levene's test of homogeneity of variances was applied and potential outliers were analyzed.

To investigate if the measured time of heart rate data in the different modalities were different, a one-way ANOVA was carried out on the mean total time measured for each participant in ball games, CrossFit, and running.

The present study wanted to investigate differences in time spent in high-, moderate-, and low-intensity during the three modalities and differences between the subgroup's children and adolescents, and girls and boys. This was done with two three-way mixed ANOVA with two within-subject factors, intensity and modality and one between-subject factor; boys and girls in the first mixed ANOVA and children and adolescents in the second mixed ANOVA. If the sphericity of any factors was < 0.05, the greenhouse-geisser correction was applied. The two three-way mixed ANOVA was applied to both normalized and absolute heart rate data. A multiple comparison test with Bonferroni's correction was applied to compare different group means.

To detect differences in the ordinal data from the PACES scores and ratings of perceived exertion scores of the three modalities in all the participants and each subgroup, Friedman tests were applied to each group. Wilcoxon Signed-rank tests using Bonferroni's correction were applied to compare the group median. Differences between the two independent groups children and adolescents, and girls and boys in the three modalities and overall were detected using Mann-Whitney U tests. PACES scores through time in week 2, 6, and 11 were analyzed through Friedman tests in all the participants and the four subgroups, following Wilcoxon Signed-rank tests to compare group medians. Mann Whitney U tests were also applied here to detect any differences between the two groups of children and adolescents, and girls and boys in week 2, 6, 11, and overall the intervention.

Attendance rates were divided into three time periods; 1-4 weeks, 5-8 weeks, 9-12 weeks, and the overall attendance rate for the whole intervention. The ordinal attendance rate data were analyzed with Friedman tests on all the participants and the four subgroups and Wilcoxon Signed-rank tests to detect differences of the group medians through the three time points 1-4 weeks, 5-8 weeks, and 9-12 weeks. Furthermore, Mann-Whitney U tests were applied to see if there were any differences between the two groups children and adolescents, and girls and boys in the time points.

All statistical analyses were performed with IBM SPSS Statistics version 27.01.0 (2021, New York, USA), and results were defined as statistically significant if $P < 0.05$.

Results

Heart rate data

The analysis showed a difference in minutes spent during the three modalities ($F(1.723;89.602) = 4.788$, $P = 0.014$). The post hoc analysis showed that the time measured in ball games training (39.5 minutes) was significantly lower than the time measured in running training (44.2 minutes) ($P = 0.034$). Therefore, time spent in each heart rate zone was analyzed and presented in both absolute time and normalized time.

Time spent in intensity zones during ball games, CrossFit, and running training

The normalized Heart rate data showed a main effect of time spent in the three intensity zones ($F(2;96) = 136.310$, $P < 0.001$). The post hoc analysis showed a greater time spent in moderate-intensity (63.2 %) compared to low-intensity (22.0 %) ($P < 0.001$) and high-intensity (14.0 %) ($P < 0.001$). No main effect of time spent in the three modalities was found ($F(1;48.018) = 0.116$, $P = 0.735$). However, an intensity and modality interaction was found ($F(3.011;144.551) = 3.116$, $P = 0.028$). Post hoc analysis showed that the participants spent more time in the moderate-intensity zone during ball games (66.8 %) compared to CrossFit (60.6 %) ($P = 0.021$), furthermore the participants spent less time in the high-intensity zone

during ball games (10.6 %) compared to CrossFit (16.4 %) (P = 0.010) and running 14.9 %) (P = 0.025), Figure 2. A.

For the absolute heart rate data, a main effect of time spent in the three intensity zones was found ($F(2;96) = 127.096$, $P < 0.001$). The post hoc showed a higher mean time spent in the moderate-intensity zone (27.5 minutes) compared to the low-intensity zone (9.7 minutes) ($P < 0.001$) and high-intensity zone (6.0 minutes) ($P < 0.001$). Furthermore, a higher amount of time was spent in the low-intensity zone compared to the high-intensity zone ($P = 0.049$). According to time spent in each modality, a main effect was found $F(1.758;84.369) = 5.850$, $P = 0.006$). The post hoc test showed a lower mean time measured in ball games (13.6 minutes) compared to running (15.1 minutes) ($P = 0.006$). The intensity and modality showed no interaction ($F(3.373;161.896) = 1.303$, $P = 0.274$), Figure 2. B.

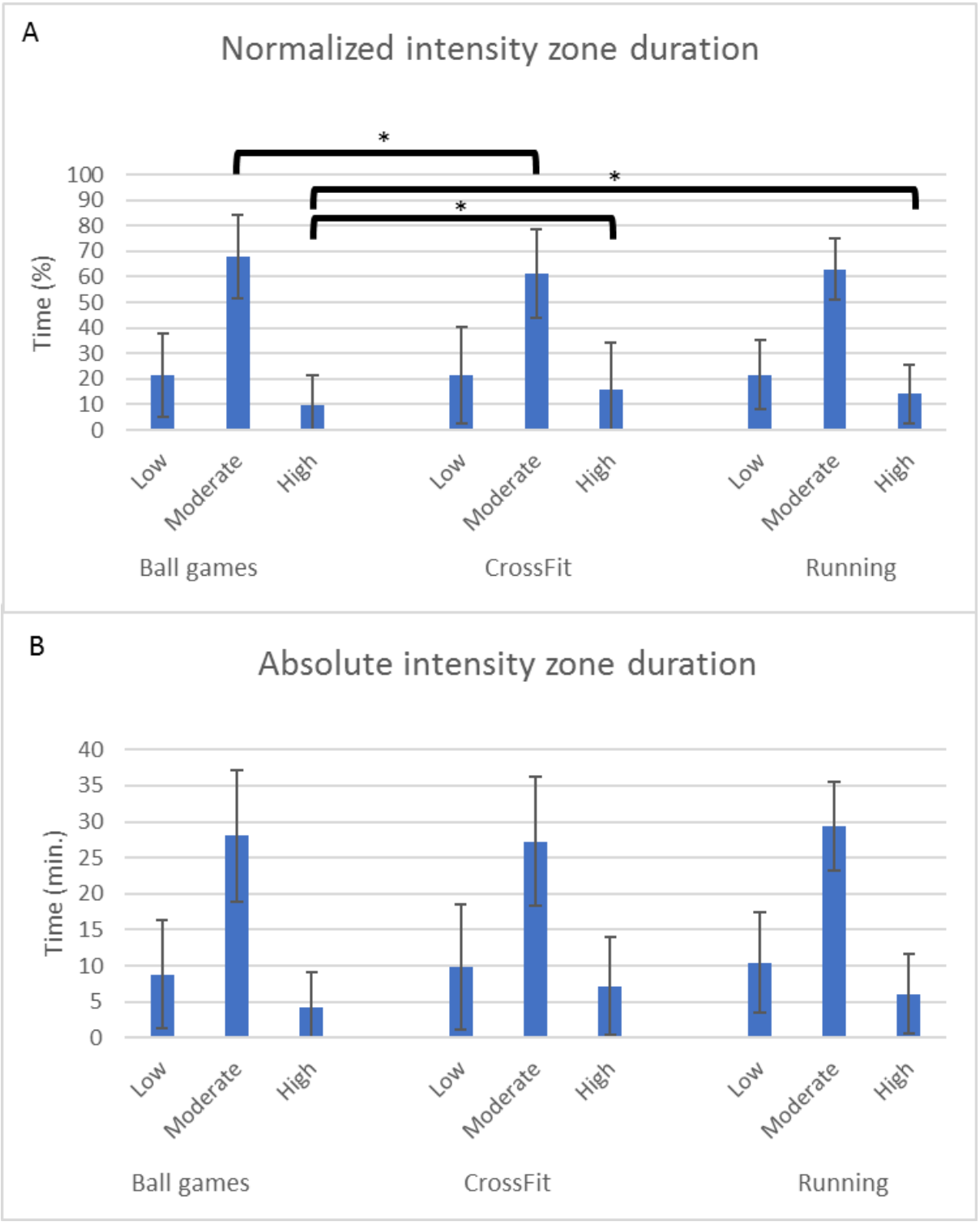


Figure 2. A: Time in percentage spent in low-, moderate-, and high-intensity zones during ball games, CrossFit, and running. Data are represented as mean ± SD. Figure 2. B: Time in minutes spent in low-, moderate-, and high-intensity during ball games, CrossFit, and running. Data are represented as mean ± SD. Significant differences is an asterisk; *P < 0.05, **P < 0.01, and ***p < 0.001.

Girls and boys

The normalized heart rate data showed no intensity and sex interaction (F(2;96) = 2.650, P = 0.076). Nor was there any modality and sex interaction (F(1;48.018) =

0.117, P = 0.734) Figure 3. A. Lastly, no sex, modality, and intensity interaction was found (F(3.011;144.551) = 0.773, P = 0.512), Figure 4. A.

With the absolute heart rate data a intensity and sex interaction was found (F(2;96) = 4.452, P = 0.014). Post hoc revealed a difference in the moderate-intensity zone where boys spent (30.4 minutes) and girls (24.6 minutes) (P = 0.002), Figure 3. B. When looking at the modality and sex, no interaction was found (F(1.758;84.369) = 0.002, P = 0.995). Lastly, no sex, modality, and intensity interaction was found (F(3.373;161.896) = 1.847, P = 0.134), Figure 4. B.

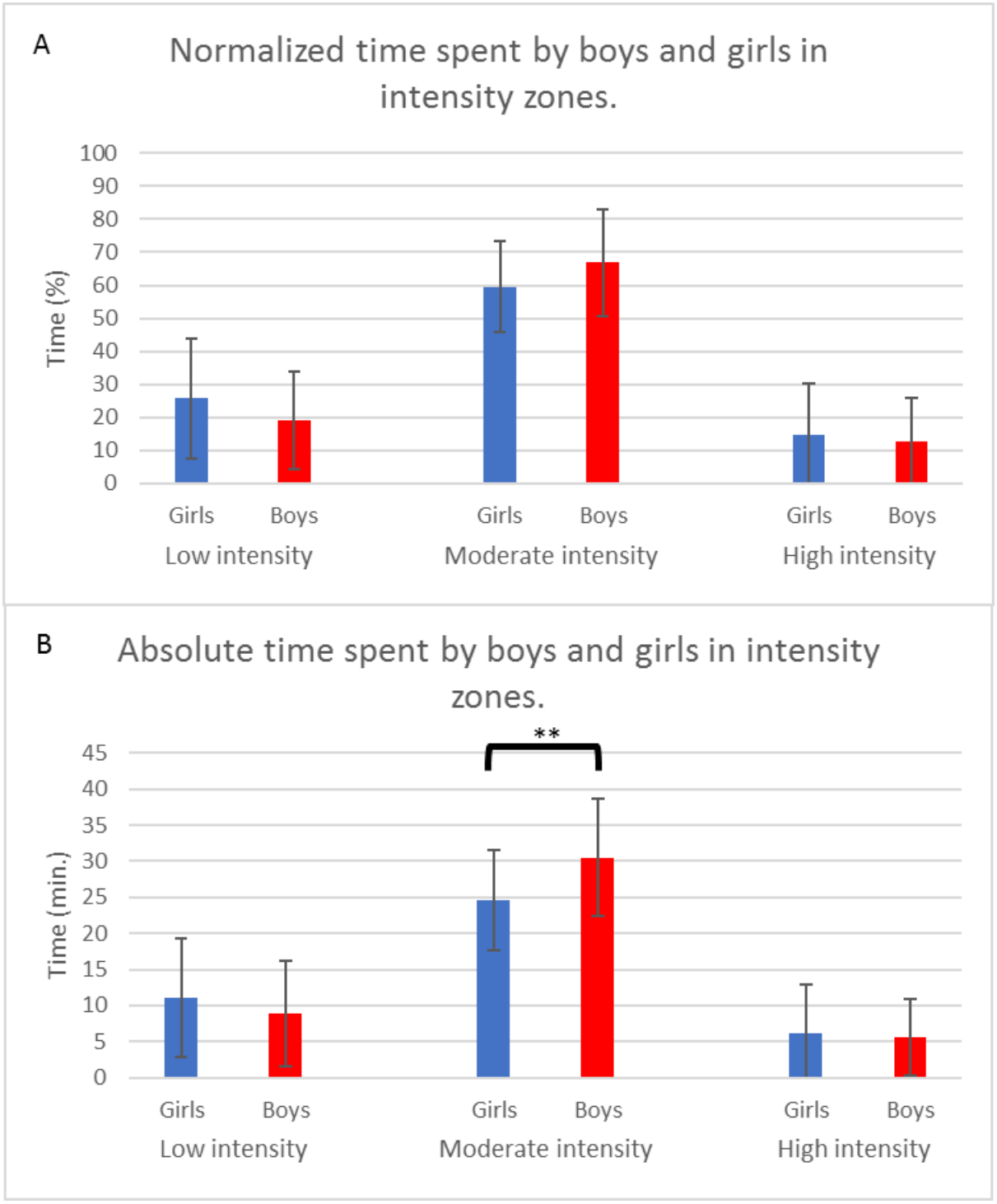


Figure 3. A: Time in percentage spent by boys and girls in low-, moderate-, and high-intensity zones. Data are represented as mean ± SD. Figure 3. B: Time in minutes spent by boys and girls in low-, moderate-, and high-intensity. Data are represented as mean ± SD. Significant differences is an asterisk; *P < 0.05, **P < 0.01, and ***p < 0.001.

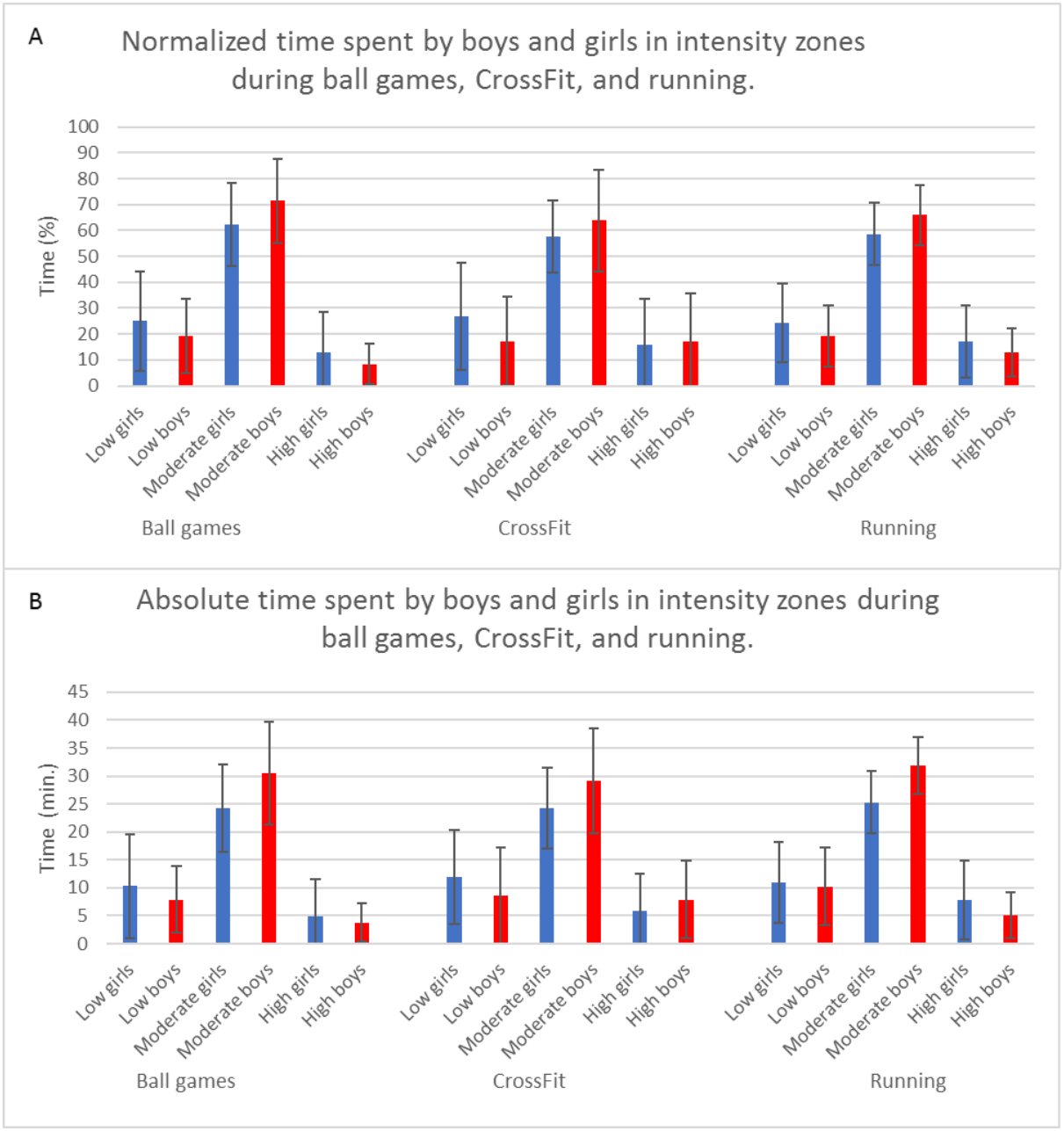


Figure 4. A: Time in percentage spent by boys and girls in low-, moderate-, and high-intensity zones during Ball games, CrossFit, and running. Data is represented as mean ± SD. Figure 4. B: Time in minutes spent by boys and girls in low-, moderate-, and high-intensity during Ball games, CrossFit, and running. Data is represented as mean ± SD.

Children and adolescents

Analysis of the children and adolescents normalized heart rate data showed no age by intensity interaction ($F(2;96) = 0.089$, $P = 0.915$). Nor was there any age by modality interaction ($F(1;48.019) = 2.633$, $P = 0.111$), Figure 5. A. Lastly, no age, modality, and intensity interaction was found ($F(3.027;145.274) = 0.146$, $P = 0.933$), Figure 6. A.

For the absolute heart rate data no intensity and age interaction was found ($F(2;96) = 0.131$, $P = 0.877$), Figure 5. B. When looking at the modality and age interaction, no interaction was found ($F(1.757;84.342) = 0.045$, $P = 0.940$). Lastly, no age, modality, and intensity interaction was found ($F(3.322;159.448) = 0.275$, $P = 0.862$) Figure 6. B.

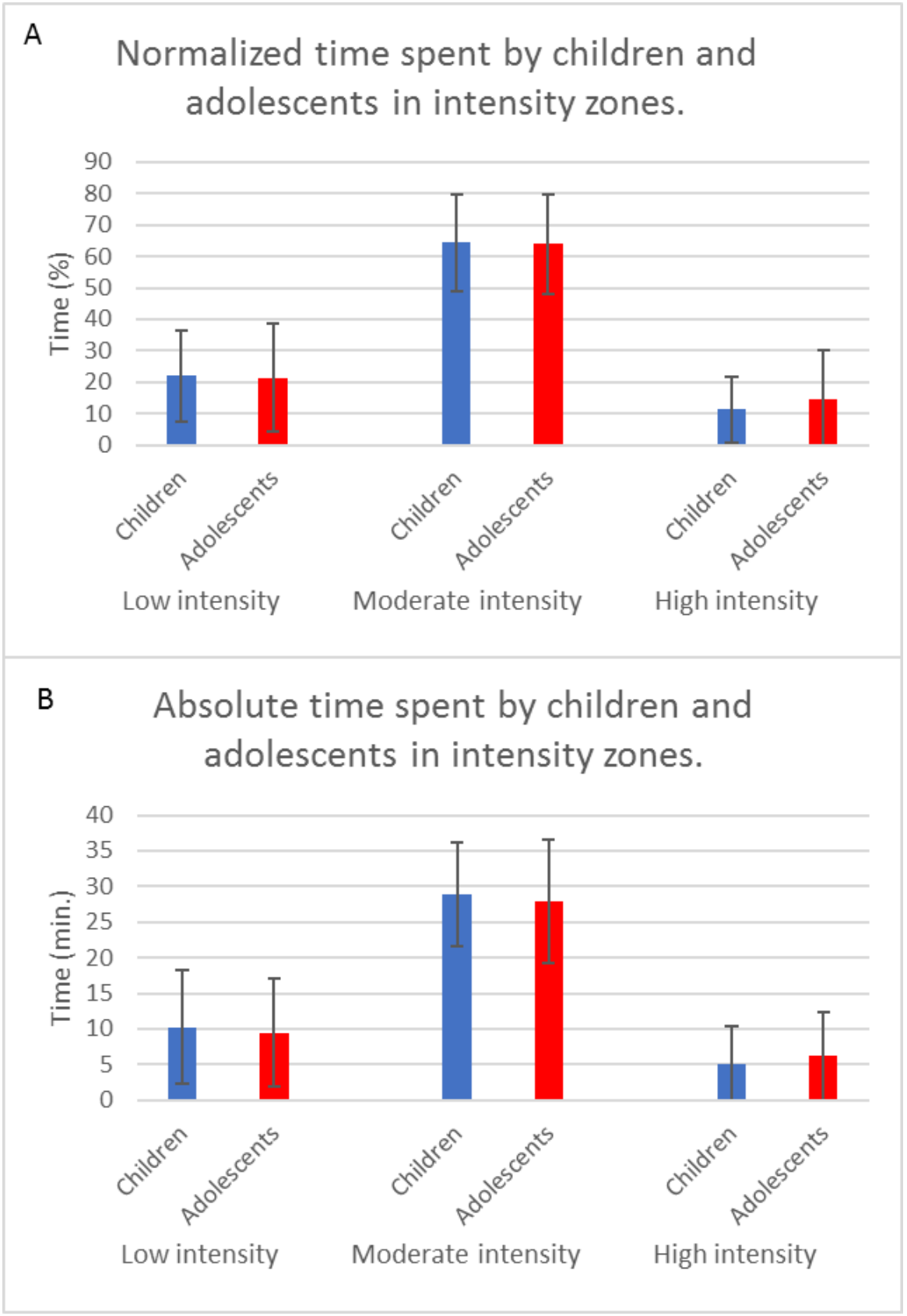


Figure 5. A: Time in percentage spent by children and adolescents in low-, moderate-, and high-intensity zones. Data are represented as mean ± SD. Figure 5. B: Time in minutes spent by children and adolescents in low-, moderate-, and high-intensity. Data are represented as mean ± SD.

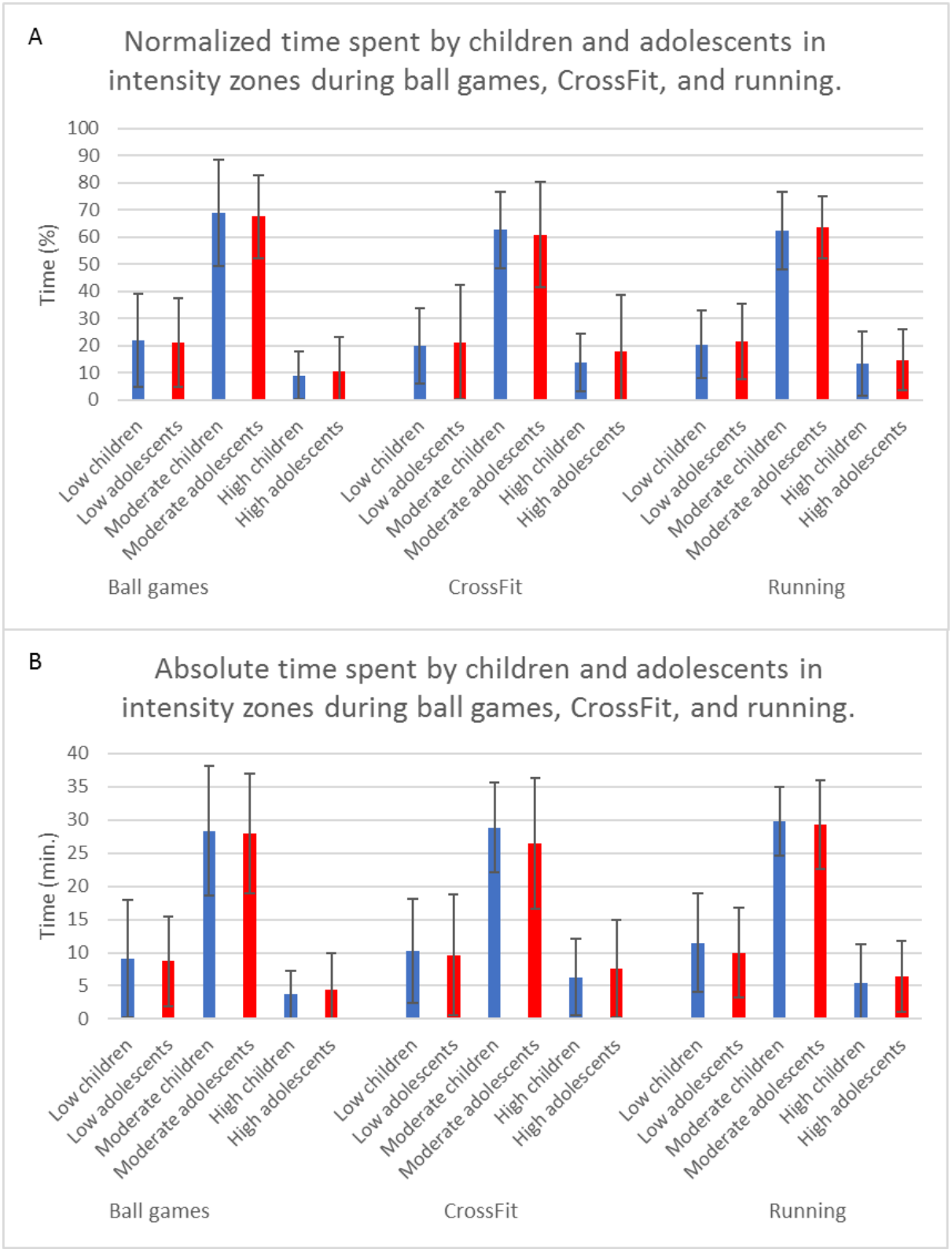


Figure 6. A: Time in percentage spent by children and adolescents in low-, moderate-, and high-intensity zones during Ball games, CrossFit, and running. Data are represented as mean ± SD. Figure 6. B: Time in minutes spent by children and adolescents in low-, moderate-, and high-intensity during Ball games, CrossFit, and running. Data are represented as mean ± SD.

Attendance rate

All the participants (combined) showed significant findings across the three time points week 1-4, week 5-8, and week 9-12 ($\chi^2(2) = 21.556$, $P < 0.001$). The post hoc analysis showed a decline from weeks 1-4 (91.7 %) to week 5-8 (75.0 %) ($Z = -2.965$, $P = 0.003$) and week 9-12 (75.0 %) ($Z = -4.832$, $P < 0.001$). Additionally, a difference was found from week 5-8 to week 9-12 ($Z = -2.737$, $P = 0.006$), Figure 7 and 8.

Girls and boys

The analysis of Attendance rate for girls and boys, revealed a significant result for girls over the three time points week 1-4, week 5-8, and week 9-12 ($\chi^2(2) = 11.054$, $p = 0.004$). The post hoc test revealed a decline from week 1-4 (91.7 %) to week 9-12 (75.0 %) ($Z = -2.731$, $P = 0.006$). The boys also showed a significant result over time ($\chi^2(2) = 11.965$, $P = 0.003$). Post hoc analysis showed a decline from week 1-4 (83.3 %) to week 5-8 (75 %) ($Z = -2.561$, $P = 0.010$) and week 9-12 (66.7 %) ($Z = -4.001$, $P < 0.001$), Figure 7.

The interaction between boys and girls in each time period and overall the intervention, had no significant differences, with all P-values being higher than ($Z = -0,985$ $P = 0.325$), Figure 7.

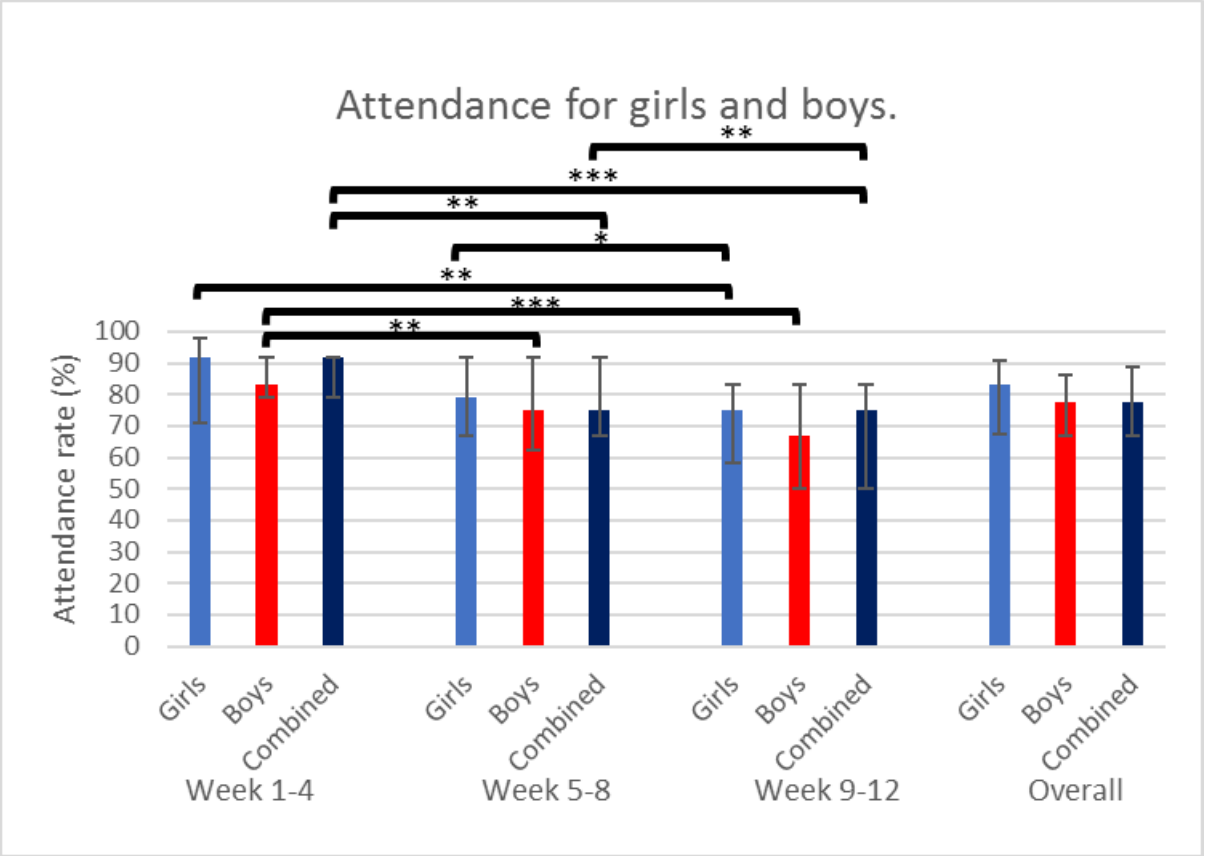


Figure 7: Attendance rate in percentage for boys, girls, and combined in week 1-4, 5-8, 9-12, and overall the whole intervention. Data are represented as median (Q1-Q3). Significant differences is an asterisk; *P < 0.05, **P < 0.01, and ***p < 0.001.

Children and adolescents

The analysis of Attendance rate for children and adolescents, showed a decline for children over time ($\chi^2(2) = 10.742$, P = 0.005). The post hoc test revealed a decline from week 1-4 (91.7 %) to week 5-8 (79.2 %) (Z = -2.945, P = 0.003) and 9-12 (83.3 %) (Z = -2.540, P = 0.011). The adolescents also showed a decline over time ($\chi^2(2) = 17.197$, P < 0.001). Post hoc analysis showed a decline from week 1-4 (83.3 %) to week 9-12 (66.7 %) (Z = -4.104, P < 0.001). Additionally, the post hoc showed a decline from week 5-8 (75.0) to week 9-12 (Z = -3.211, P = 0.001), Figure 8.

The interaction between children and adolescents in each time period and overall the intervention had a difference in weeks 9-12 (Z = -2.150, P = 0.032), where the children had an attendance rate of 83.3 % and the adolescents had an attendance rate of 66.7 %, Figure 8.

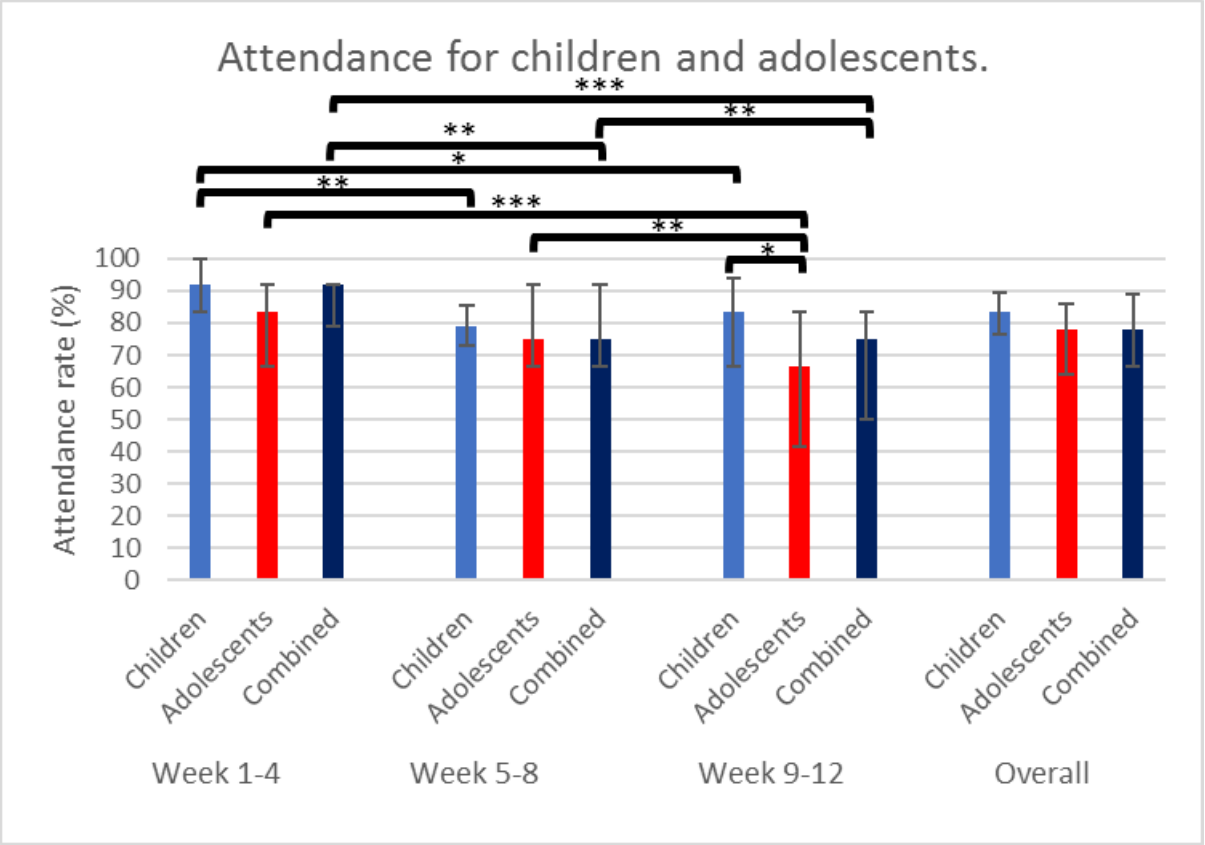


Figure 8: Attendance rate in percentage for children and adolescents, and combined in week 1-4, 5-8, 9-12, and overall the whole intervention. Data are represented as median (Q1-Q3). Significant differences are an asterisk; *P < 0.05, **P < 0.01, and ***p < 0.001.

Enjoyment of physical activity

All the participants (combined) showed no significant results across the modalities ($\chi^2(2)= 2.098$, P = 0.350). PACES across time in week 2, 6, and 11 also showed no results for all the participants (combined) ($\chi^2(2)= 2.878$, P = 0.237), Figure 9. A and 10. A.

Girls and boys

The analysis of the PACES Questionnaire for girls and boys during ball games, CrossFit, and running showed no differences for girls or boys across the modalities, with the lowest P-value being the boys ($\chi^2(2)= 1.486$, P = 0.476). Nor was any difference found between girls and boys in each modality and overall the intervention, with the lowest P-value being in running (Z = -1.579, P = 0.114), Figure 9. A.

When looking at the PACES score over time in week 2, 6, and 11 no differences for girls or boys were found with the lowest P-value being for the boys

($\chi^2(2) = 3.468$, P = 0.177). Looking at the difference for girls and boys within each time point and overall the intervention, no difference was found, with the lowest P-value being in week 2 (Z = -1.817, P = 0.069), Figure 9. B.

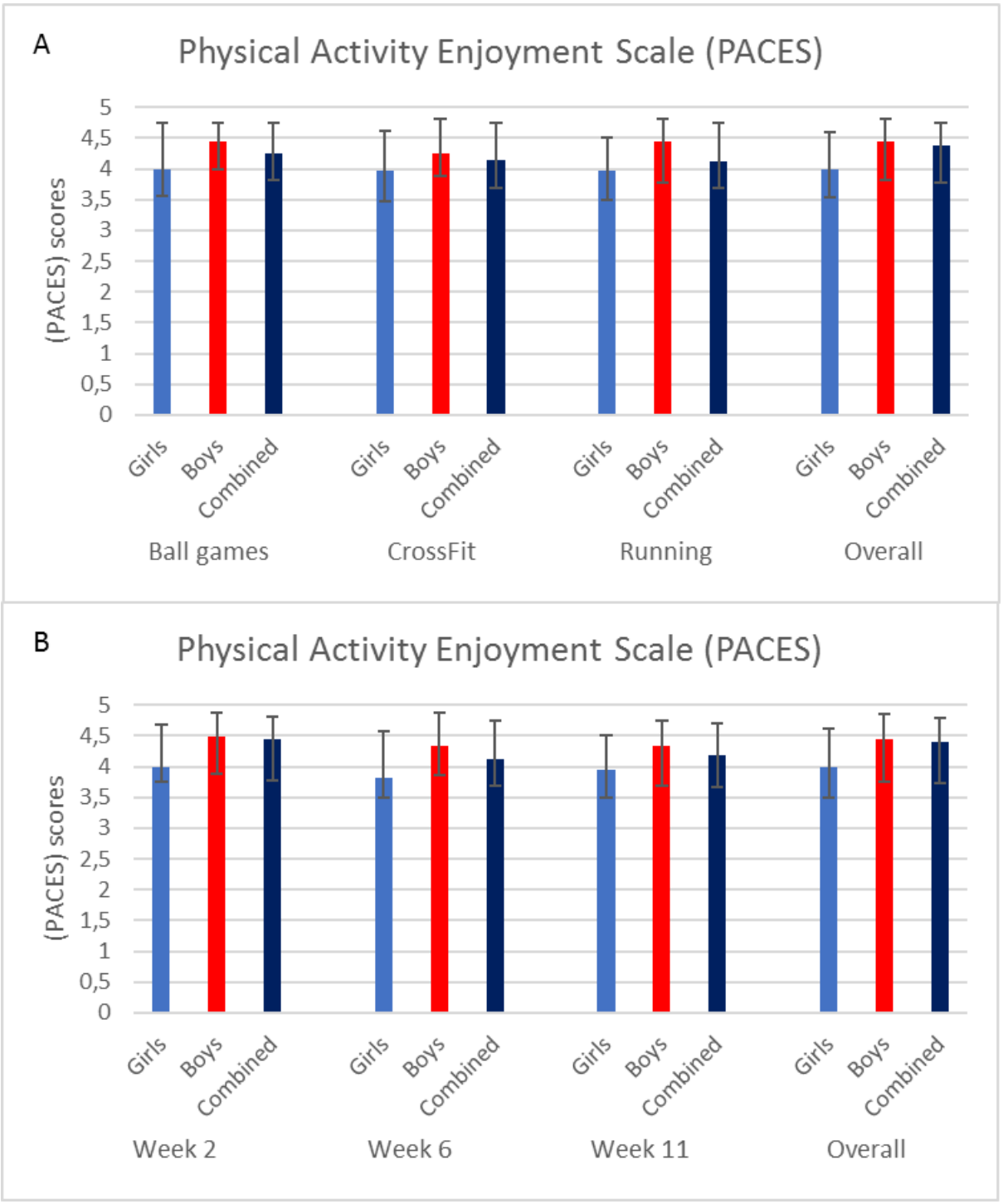
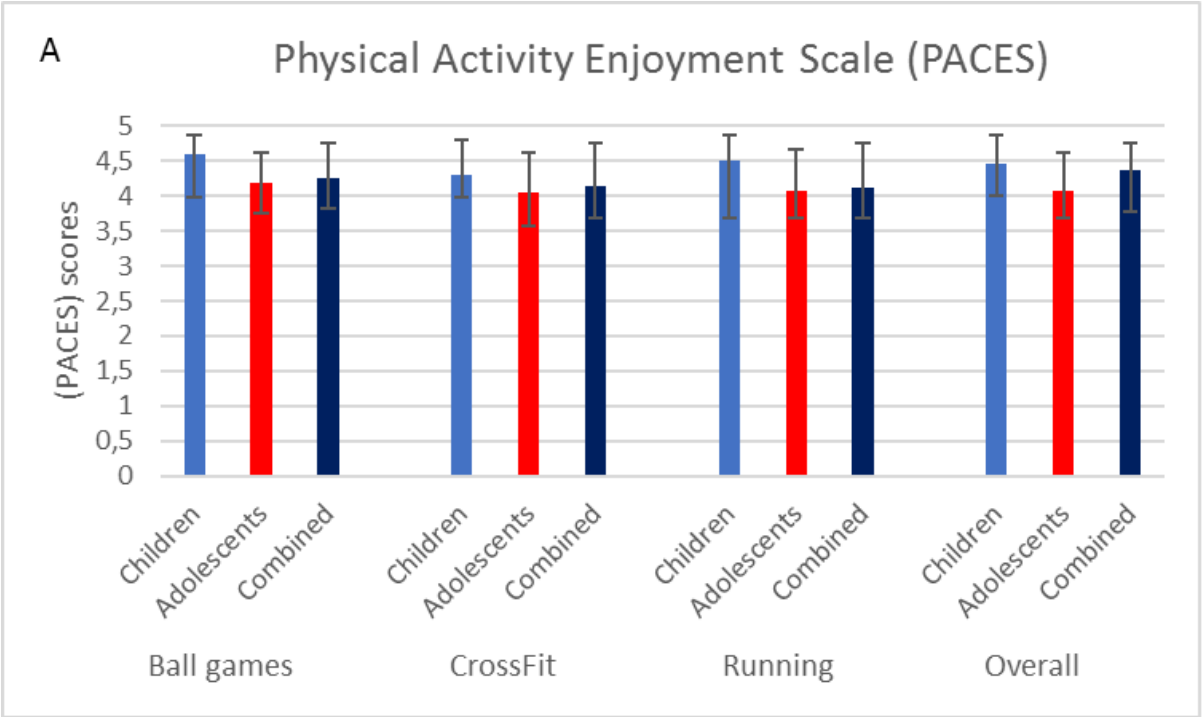


Figure 9. A: Physical Activity Enjoyment Scale (PACES) for boys, girls, and combined in each modality and overall the intervention. Figure 9. B: PACES for boys, girls, and combined in week 2, 6, 11, and overall the intervention. Data are represented as median (Q1-Q3).

Children and adolescents

The analysis of the PACES Questionnaire for children and adolescents during ball games, CrossFit, and running showed no differences, for children or adolescents across the modalities, with the lowest P-value being for the adolescents ($\chi^2(2)= 2.517$, $P = 0.280$). Nor was any difference found between girls and boys in each modality and overall the intervention, with the lowest P-value being in ball games ($Z = -1.588$, $P = 0.112$), Figure 10. A.

When looking at the PACES score over time in week 2, week 6, and week 11, no differences between children and adolescents were found, with the lowest P-value in children ($\chi^2(2) = 1.800$, $P = 0.407$). Looking at the difference for children and adolescents within each time point and overall the intervention, no difference was found with the lowest P-value being in overall the intervention ($Z = -1.598$, $P = 0.110$), Figure 10. B.



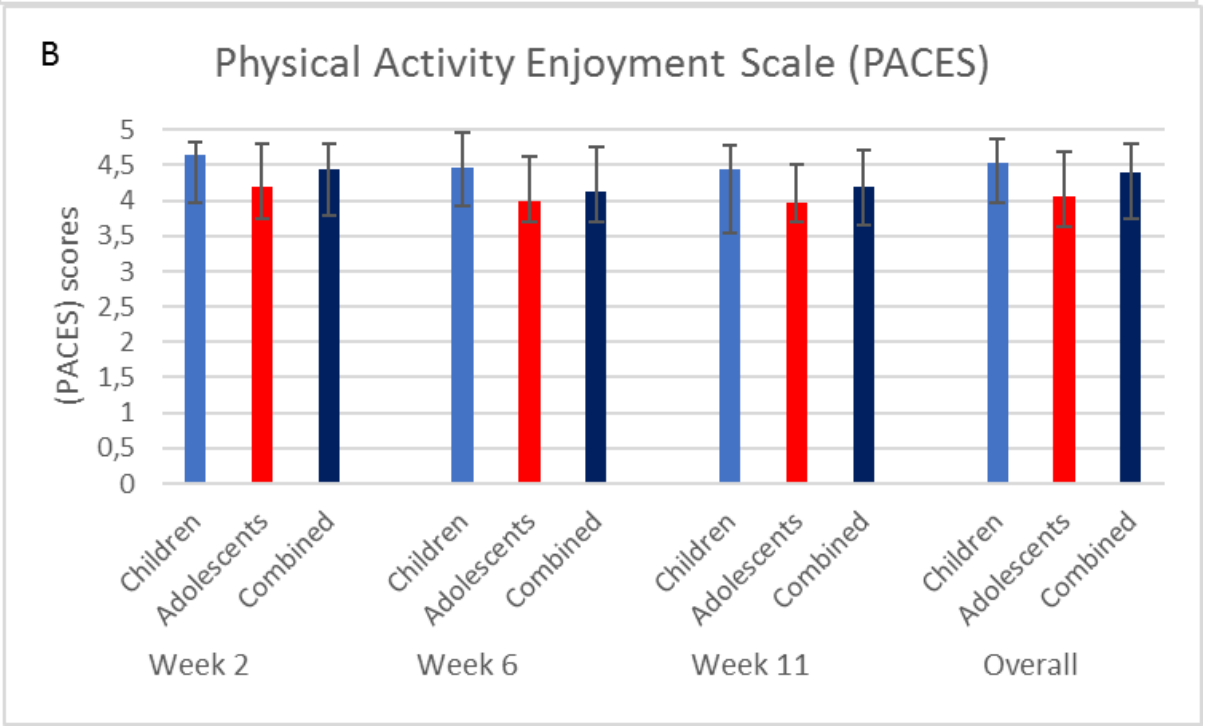


Figure 10. A: Physical Activity Enjoyment Scale (PACES) for children, adolescents, and combined in each modality and overall the intervention. Figure 10. B: PACES for children, adolescents, and combined in week 2, 6, 11, and overall the intervention. Data are represented as median (Q1-Q3).

Ratings of perceived exertion

Analysis of Ratings of perceived exertion data for all the participants (combined) showed significant results across the three modalities ball games, CrossFit, and

running ($\chi^2(2)= 10.433$, P = 0.005). The post hoc analysis showed an increase in perceived exertion from ball games (5.3) to CrossFit (6.0) (Z = -3.103, P = 0.002) and running (6.0) (Z = -2.997, P = 0.003), Figure 11 and 12.

Girls and boys

The analysis of the ratings of perceived exertion data for girls and boys during ball games, CrossFit, and running showed no significant results with the lowest P-value in boys ($\chi^2(2)= 5.902$, P = 0.052), Figure 11.

No differences were found between girls and boys in each modality and overall the intervention, with the lowest P-value being in running (Z = -0.306, P = 0.759), Figure 11.

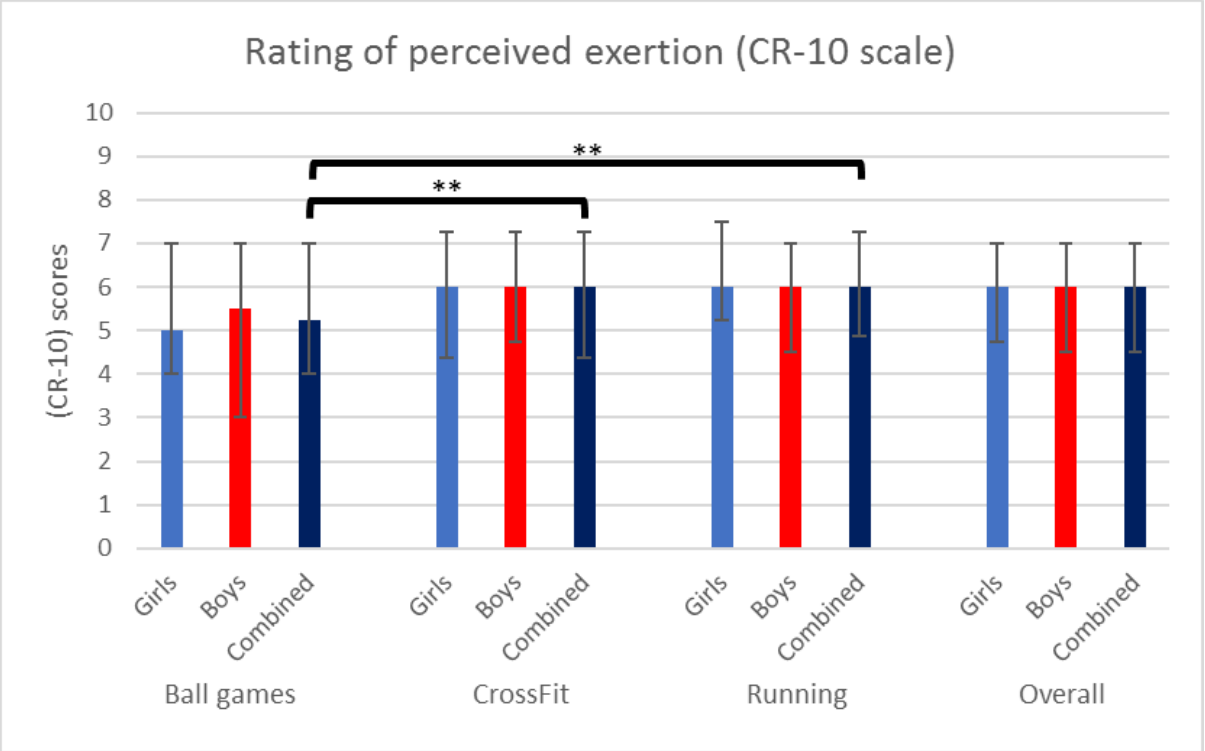


Figure 11: Ratings of perceived exertion (CR-10 scale) for girls, boys, and combined in each modality and overall the intervention. Data is represented as median (Q1-Q3). Significant differences are an asterisk; *P < 0.05, **P < 0.01, and ***p < 0.001.

Children and adolescents

The analysis of the perceived exertion ratings for children and adolescents during ball games, CrossFit, and running showed a significant result in the perceived exertion across the modalities for the adolescents ($\chi^2(2)= 10.621$, P = 0.005). The post hoc analysis showed that the adolescents had an increase from ball games

(5.0) to CrossFit (6.0) (Z = -2.396, P = 0.017) and running (6.0) (Z = -2.881, P = 0.004), Figure 12.

Looking at the difference between children and adolescents in each modality and overall the intervention, no significant results were found with the lowest P-value being in overall the intervention (Z = -0.775, P = 0.438), Figure 12.

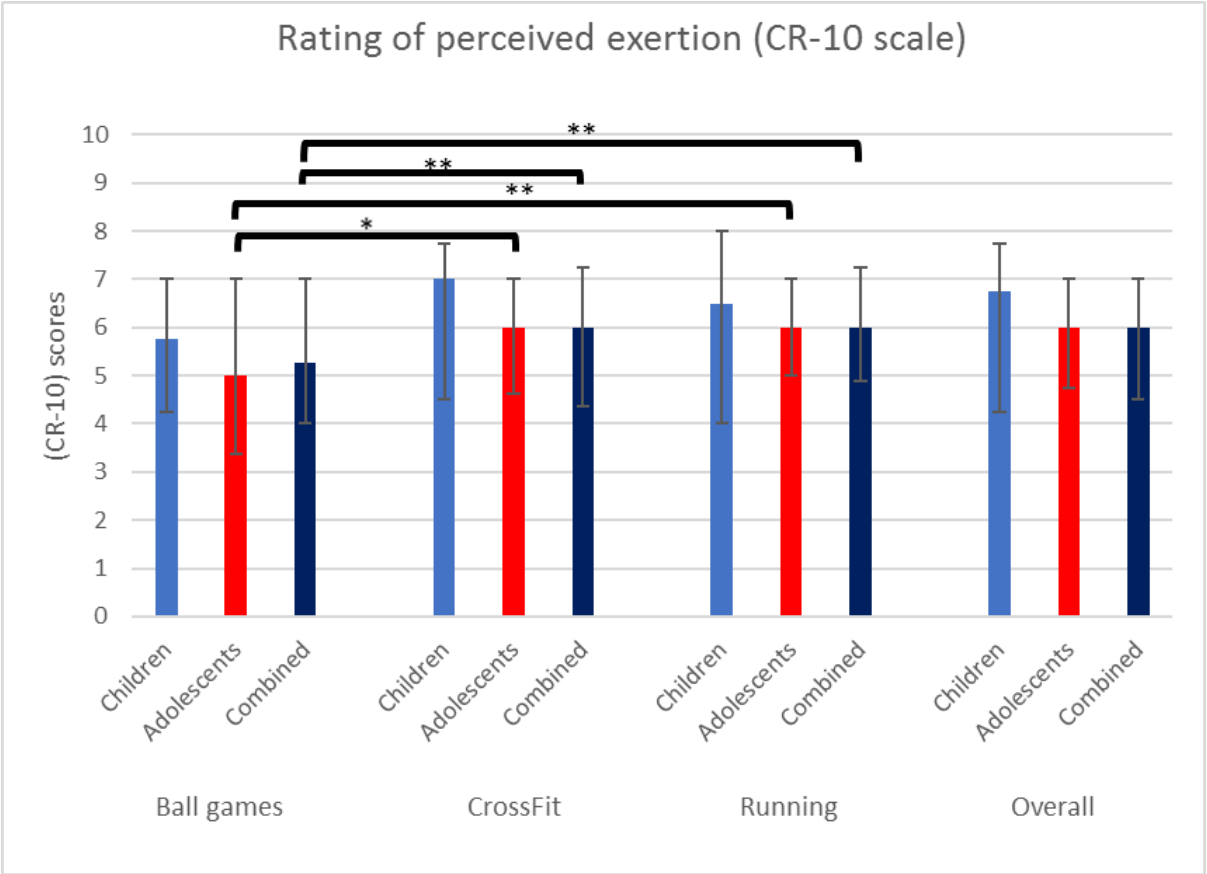


Figure 12: Ratings of perceived exertion (CR-10 scale) for children, adolescents, and combined in each modality and overall the intervention. Data is represented as median (Q1-Q3). Significant differences are an asterisk; *P < 0.05, **P < 0.01, and ***p < 0.001.

Discussion

The present study aimed to investigate the feasibility and acceptability of an ongoing 12-week community-based HIIT intervention for children and adolescents with overweight or obesity. The feasibility was evaluated through heart rate measurements during the nine training sessions in week 2, 6, and 11. This approach allowed the present study to quantify time spent in intensities, and investigate if some training modalities are better at eliciting higher heart rate during training. Acceptability of the intervention was measured through the attendance rate and dropout throughout the 12-week intervention. Additionally, perceived exertion and

enjoyment of the nine training sessions in week 2, 6, and 11 were included to investigate if some of the modalities were perceived more enjoyable and physically harder or easier than other modalities. Furthermore, feasibility and acceptability were examined in smaller subgroups investigating effects of sex (girls vs. boys) and age (children vs. adolescents), to see if they experience the training sessions different.

Feasibility

Time spent in training during the three modalities was different, the discussion of feasibility will be based on the normalized heart rate data. Difference in results between normalized and absolute heart rate data will be discussed in methodical considerations.

The present study results showed a significantly longer time spent in the moderate-intensity zone during ball games (66.8 %) compared to CrossFit (60.6 %). Additionally, the participants spent significantly less time in the high-intensity zone during ball games (10.6 %) compared to CrossFit (16.4 %) and running (14.9 %), Figure 2. A. These results indicate that ball games elicit less time in the high-intensity zone than CrossFit and running, but more time in the moderate-intensity zone instead. These results could be explained by impaired motor control and stability in children and adolescents with overweight or obesity, resulting in lowered skills in physical activity[28]. Ball games often involve team play and a wide range of motor skills that may induce fear in the participants because of perceived inferiority in social settings, meaning they are afraid of being judged negatively through their performance[29]. If the participants experience this fear, ball games often have different game roles or settings that allow them to step back and let the more experienced participants play to ensure they do not make any mistakes. This could indicate that ball games thereby elicit a lower time in the high-intensity zone because of lesser participation.

Boys and girls and children and adolescents

The normalized data showed no significant age, intensity, and modality interactions, Figure 5. A and 6. A. This is surprising since adolescents with obesity typically develop lower self-esteem because of lowered mobility, making them nervous regarding physical activity[27-29]. Additionally, children may not have developed this

lowered self-esteem yet, and seem to favor game-based physical activity[29,30]. It could be argued that the present intervention matches the description of a game-based intervention since it consists of different training sessions with different modalities and different games incorporated into these modalities. One explanation for the non-significant result between children and adolescents may be that the training teams consist of equal peers who are overweight or obese. That may help with the adolescents' potential lowered self-esteem and thereby encourage them to participate[29].

Data for girls and boys showed no significant differences, this is surprising since different motivational factors have been established for sexes[21]. Different studies found that boys are motivated by competition and better performance in sports, while girls preferred social interaction and friendship with peers during physical activity[21,23,24]. In addition to this, boys tend to prefer physical activities that involve physical contact whereas girls prefer sociability and game-based activities[21,24-26]. No sex, intensity, and modality interaction was found, Figure 3. A and 4. A. An explanation for these nonsignificant results may be because the present intervention constitutes settings with equal peers who are overweight or obese and physical activities that both match the game-based activities for the girls, and the competition element that motivates the boys.

The goal of each training session was to achieve 16 minutes in the high-intensity zone, hence the 4 x 4-minute intervals. This was not achieved in the present study with the following mean times in the high-intensity zone; boys (5.7 minutes), girls (6.4 minutes), children (5.5 minutes), and adolescents (6.2 minutes) equal to 71.4 minutes of high-intensity weekly physical activity. Although the 16 minutes in high-intensity was not achieved, it is still promising according to earlier measurements from the National Health and Nutrition Examination Surveys from 2003-2004 and 2005-2006[38]. They reported a daily mean time in the high-intensity zone for obese children and adolescents as following; boys (5.6 minutes), girls (2.3 minutes), children (6.0 minutes), and adolescents (3.0 minutes) equal to 117.6 minutes of high-intensity weekly physical activity[38]. Taking these numbers into account, it can be argued that if the children and adolescents on a weekly basis perform 117.6 minutes of high-intensity physical activity while getting 71.4 minutes of high-intensity zone physical activity from the present 12-week community-based HIIT intervention is a big step in the right direction.

Acceptability

Attendance rates and dropouts

The present community-based HIIT intervention participants had an overall median attendance rate of 77.8 %, whereas the subgroups had the following attendance rates; girls 83.3 %, boys 77.8 %, children 83.3 %, and adolescents 77.8 %. In a study by Alberga et al. (2019), a threshold of 70 % attendance rate was established where an attendance below 70 % was considered a low attendance rate and an attendance rate above was considered a high attendance rate[12]. With this threshold in mind, the attendance rate in the present study was high.

Looking at the attendance results from girls and boys and children and adolescents, a tendency is seen where the girls and children have a higher attendance rate over time than boys and adolescents, Figure 7 and 8. These findings may be explained through the enjoyment over time since it has been stated that a high enjoyment of physical activity is a predictor of high attendance rates[12,30,39-41]. The enjoyment of physical activity over time for children and adolescents (Figure 10. B) aligns with the attendance rate since a tendency for higher enjoyment is seen in children who have a higher attendance rate. However, looking at the enjoyment of the girls and boys, (Figure 9. B), the boys tend to have a higher enjoyment of physical exercise even though the boys attendance rate was lower than the girls. It is difficult to explain why this opposite tendency is seen and data about the reasons for non-participation would have been helpful to answer this question. These data, however, are lacking in the current study, either because of trainers who forgot to register it or because the parents or participants gave no reason.

Through weeks 1-4, 5-8, and 9-12, a significant decrease in attendance rate is seen from the first four weeks of the intervention (Figure 7 and 8), even though no decrease is seen in the enjoyment of the physical activity over time, Figure 9. B and 10. B. The significant decreases in attendance rate and the significant difference between children and adolescents in weeks 9-12, can be explained through a study by Nguyen et al. (2015) who states that attendance rates of overweight and obese adolescents decline over time[19]. Nguyen et al. (2015) state that the attendance rates are highest in the first two months of the intervention and then decline. Some of the main reasons for this decline were transport issues, illness, and family commitments. Illness and family commitments are difficult to overcome, and the transport issues

are already at a minimum because the training sessions in this intervention take place in local gymnastic halls. The same decline over time is seen in obese children, where Jones et al. (2009) suggests phoning the participants the day before to remind them of the training session, which is seen in other studies[20,42]. This would maybe help the participants over time and keep them motivated to keep participating in longer interventions.

The present study had ten dropouts corresponding to a 15.9 % dropout rate, which is low compared with similar studies with a dropout rate from 19.4 to 28.2 %[16,43]. One main reason for the high dropout rate of 28.2 % may be explained by the length of the intervention, which was 13 months, while the intervention of the present study and Tjønna et al. (2009) lasted three months[16]. Another reason for the low dropout rate in the present study is because of its explorative nature. This means that no participants were excluded during the intervention because of low attendance rate, as in Alberga et al. (2019), which might have lowered the dropout rate[12].

Enjoyment of physical activity

The PACES data showed no significant differences across the three modalities or between girls and boys and children and adolescents. However, despite no significant results in the PACES, all participants rated the 12-week community-based intervention high; combined 4.4, girls 4.0, boys 4.5, children 4.5, and adolescents 4.0, Figure 9. A and 10. A. This high enjoyment of physical activity matches other studies with a similar protocol for children[30] and adolescents[20,39]. In the present study a tendency toward a higher enjoyment of physical activity is seen in children compared to adolescents, Figure 10. A. Lambrick et al. (2016) showed similar results in children between 8-10 years old using a HIIT intervention that lasted six weeks, with 60 minutes of training sessions that included different playful games[30]. The children in Lambrick et al. (2016) scored the enjoyment of physical activity to 4.5 with the same PACES used in the present study. An explanation of these similar results may be because of the similar training sessions that have varying training exercises, which is related to a higher enjoyment of the physical activity since the training is observed to be more play-like for the children[30,44]. A study that showed similar enjoyment of physical activity in adolescents as the present study in a HIIT intervention is Murphy et al. (2014) who reported 85 out of 100[39]. The intervention included obese adolescents between 12-18 years old and lasted four weeks.

Participants trained 50 minutes four times each week with 1-minute HIIT bouts. A reason for the high enjoyment of physical activity in Murphy et al. (2014) can be due to the use of incentives. The adolescents were given a 10-dollar gift card if they attended at least 3 out of 4 weekly training sessions, which might have affected the attendance rate and the enjoyment of physical activity[39].

A second tendency is seen between girls and boys, where boys tend to have a higher enjoyment of physical activity than girls. To this study's authors' knowledge no other studies have compared the enjoyment of physical activity between girls and boys on a 12-week community-based HIIT intervention with different modalities incorporated. However, an explanation for the lower enjoyment of physical activity in girls compared to boys may lie in the fact that obese adolescents, especially girls, have a higher body dissatisfaction than normal-weight adolescents at the same age[12,45]. This could mean that the adolescent girls in the present study have lower self-esteem and thereby feel nervous about doing physical activity which could mean the girls did not enjoy the physical activity to the same degree as boys who are less appearance orientated[27].

Ratings of perceived exertion

The ratings of perceived exertion were considered in the present study to see if the participants perceived any of the three modalities more exhausting than other modalities. Additionally, the present study wanted to see if girls and boys and children and adolescents perceived the whole intervention and each modality harder than one another and if the perceived exertion matched the time spent in each modality.

No significant results in perceived exertion were seen between girls and boys and children and adolescents in any modality, or the three modalities combined. However, when looking at all the participants (combined) a significantly higher perceived exertion in CrossFit (6.0) and running (6.0) compared to ball games (5.3) can be seen, Figure 11 and 12. These perceived exertion scores match well with the time spent in intensity zones, where a significant increase in the normalized time spent in the high-intensity zone was seen from ball games (10.6 %) to CrossFit (16.4 %) and running (14.9 %), Figure 2. A. This agreement between these different perceived exertion scores and the different time spent in high-intensity zones matches well with the good correlation between the Borg CR-10 scale and a

normal-weight person's heart rate[46]. Additionally, a significant increase in perceived exertion was shown for adolescents from ball games (5.0) to CrossFit (6.0) and running (6.0), Figure 12. These significant results do not match any significant result from the time spent in intensity zones. However, a trend can be seen in the high-intensity zone for the adolescents who spend less time in the high-intensity zone during ball games (10.5 %) compared to CrossFit (17.9 %) and running (14.8 %), Figure 6. A. This trend may explain why the adolescents perceived exertion was significantly higher during CrossFit and running compared to ball games.

Methodical considerations

The present study found a significantly different training time based on heart rate recordings in the different modality training sessions. The optimal measurement time would have been 40 minutes every training. However, this was not the case with a mean measure time of 39.5 minutes in ball games, 43.4 minutes in CrossFit, and 44.2 minutes in running. It is not known exactly why different measure times are present. However, it could be due to connection issues because the participants were overweight or obese the equipment sometimes had problems reading the heart rate. Another explanation could be because of an early or late start of measurements, meaning heart rate is either measured before or after the training session ended or variation of training length, resulting in the probability of misleading data. These different measure times gave different significant outcomes when the heart rate was either normalized or absolute. These differences were found in the time spent in intensity zones during the three modalities where the absolute data showed no significant differences in contrast to the normalized data previously discussed, Figure 2. A and 2. B. Another difference appeared between boys and girls in the time spent in intensity zones, where no significant difference was found in the normalized data, but the boys spent a significantly greater time in absolute minutes compared to girls in the moderate-intensity zone, Figure 3. A and 3. B. Future projects should be aware of this plausible problem.

According to the attendance rate, reasons for absence were badly described either because the trainers forgot to write down the reason, or the parents or participants did not give any reason for the absence. Such data would have been helpful in narrowing down the barriers, and reasons for the decline in attendance rate

over time when dealing with children and adolescents with overweight or obesity in a 12-week community-based HIIT intervention.

Conclusion

According to feasibility, the normalized and absolute heart rate data did not meet the intended 16 minutes in the high-intensity zone during the 12-week community-based HIIT intervention. However, CrossFit and running seem favorable to elicit more time in the high-intensity zone compared to ball games. The subgroups of sex (girls vs. boys) and age (children vs. adolescents) did not show any major differences regarding feasibility.

The acceptability of the study showed that all the participants highly liked the 12-week community-based HIIT intervention, and the ratings of perceived exertion matched well with the normalized heart rate data. The dropout rate was low and the attendance rate was high but had a decline over time in all four subgroups.

Future directions

Future studies investigating the feasibility and acceptability of a community-based HIIT intervention with children and adolescents with overweight or obesity should consider strict start and stop recording times for heart rate. This is proposed to make sure the measurements in the different training sessions are equal. Moreover, considerations regarding the decline in attendance rate should be incorporated. This could be through text messaging or phoning the participants or their parents the day before a training, to remind them of the training.

Acknowledgements

The author of the present study would like to express his gratitude toward specialist in pediatrics Charlotte Nørkjær Eggertsen for sharing data from her ongoing study. Acknowledgement goes to main supervisor Ryan Godsk Larsen, Associate Professor, MSc, PH.D., co-supervisor Morten Bilde Simonsen, MSc, PH.D., and Charlotte Nørkjær Eggertsen, specialist in pediatrics for guidance through the present study.

References

1. Overvægt og svær overvægt blandt danske børn og unge. https://www.sdu.dk/da/sif/rapporter/2020/overvaegt_og_svaer_overvaegt_blandt_boern_og_unge.

2. Reilly JJ, Kelly J. Long-term impact of overweight and obesity in childhood and adolescence on morbidity and premature mortality in adulthood: Systematic review. *International journal of obesity (2005)*. 2011;35(7):891-898.

3. Ells LJ, Rees K, Brown T, et al. Interventions for treating children and adolescents with overweight and obesity: An overview of cochrane reviews. *International Journal of Obesity 2018 42:11*. 2018;42(11):1823-1833.

4. T B, TH M, L H, et al. Interventions for preventing obesity in children. *The Cochrane database of systematic reviews*. 2019;7(7).

5. KS W, U W, JS C. High-intensity interval training in patients with lifestyle-induced cardiometabolic disease: A systematic review and meta-analysis. *British journal of sports medicine*. 2014;48(16):1227-1234.

6. García-Hermoso A, Cerrillo-Urbina AJ, Herrera-Valenzuela T, Cristi-Montero C, Saavedra JM, Martínez-Vizcaíno V. Is high-intensity interval training more effective on improving cardiometabolic risk and aerobic capacity than other forms of exercise in overweight and obese youth? A meta-analysis. *Obesity Reviews*. 2016;17(6):531-540.

7. JC H, M G, DS B, HN GNK, LC W, J F. Chronic care treatment of obese children and adolescents. *International journal of pediatric obesity : IJPO : an official journal of the International Association for the Study of Obesity*. 2011;6(3-4):188-196.

8. Barlow SE. Expert committee recommendations regarding the prevention, assessment, and treatment of child and adolescent overweight and obesity: Summary report. *Pediatrics*. 2007;120(Supplement 4):S164-S192.

9. Anbefalinger om fysisk aktivitet for børn mellem 5 og 17 år - sundhedsstyrelsen. https://www.sst.dk/da/Viden/Fysisk-aktivitet/Anbefalinger-om-fysisk-aktivitet/Boern-mellem-5-

og-17-aar.

10. Health Organization Regional Office for Europe, World. The WHO regional office for europe. https://www.euro.who.int/__data/assets/pdf_file/0003/303438/HSBC-No.7-Growing-up-unequal-Full-Report.pdf. Updated 2016.

11. Alberga AS, Medd ER, Adamo KB, et al. Top 10 practical lessons learned from physical activity interventions in overweight and obese children and adolescents. *Applied Physiology, Nutrition and Metabolism*. 2013;38(3):249-258.

12. Alberga AS, Sigal RJ, Sweet SN, et al. Understanding low adherence to an exercise program for adolescents with obesity: The HEARTY trial. *Obesity Science & Practice*. 2019;5(5):437-448.

13. Martland R, Mondelli V, Gaughran F, Stubbs B. Can high-intensity interval training improve physical and mental health outcomes? A meta-review of 33 systematic reviews across the lifespan. *https://doi.org/10.1080/02640414.2019.1706829*. 2019;38(4):430-469.

14. Thivel D, Masurier J, Baquet G, et al. High-intensity interval training in overweight and obese children and adolescents: Systematic review and meta-analysis. *The Journal of sports medicine and physical fitness*. 2019;59(2):310-324.

15. Marson EC, Delevatti RS, Prado AKG, Netto N, Kruel LFM. Effects of aerobic, resistance, and combined exercise training on insulin resistance markers in overweight or obese children and adolescents: A systematic review and meta-analysis. *Preventive medicine*. 2016;93:211-218.

16. AE T, TO S, A B, et al. Aerobic interval training reduces cardiovascular risk factors more than a multitreatment approach in overweight adolescents. *Clinical science (London, England : 1979)*. 2009;116(4):317-326.

17. Gray SR, Ferguson C, Birch K, Forrest LJ, Gill JMR. High-intensity interval training: Key data needed to bridge the gap from laboratory to public health policy. *British Journal of Sports Medicine*. 2016;50(20):1231-1232.

18. Hong I, Coker-Bolt P, Anderson KR, Lee D, Velozo CA. Relationship between physical

activity and overweight and obesity in children: Findings from the 2012 national health and nutrition examination survey national youth fitness survey. *The American Journal of Occupational Therapy*. 2016;70(5):7005180060p1.

19. Nguyen B, Shrewsbury VA, O'Connor J, et al. A process evaluation of an adolescent weight management intervention: Findings and recommendations. *Health promotion international*. 2015;30(2):201-212.

20. Herget S, Reichardt S, Grimm A, et al. High-intensity interval training for overweight adolescents: Program acceptance of a media supported intervention and changes in body composition. *International Journal of Environmental Research and Public Health*. 2016;13(11).

21. Soares J, Antunnes H, van den Tillaar R. A comparison between boys and girls about the motives for the participation in school sport. *Journal of Physical Education and Sport*. 2013;13(3):303-307.

22. Křen F, Kudláček M, Wasowicz W, Groffik D, Frömel K. Gender differences in preferences of individual and team sports in polish adolescents. *Acta Universitatis Palackianae Olomucensis, Gymnica*. 2012;42(1):43-52.

23. Chase, Dummer. The role of sports as a social status determinant for children. *Research quarterly for exercise and sport*. 1992;63(4):418-424.

24. Prusak KA, Darst PW. Effects of types of walking activities on actual choices by adolescent female physical education students. *Journal of Teaching in Physical Education*. 2002;21(3):230-241.

25. Smith A, Thurston M, Green K, Lamb K. Young people's participation in extracurricular physical education: A study of 15—16 year olds in north-west england and north-east wales: *http://dx.doi.org/10.1177/1356336X07081997*. 2016;13(3):339-368.

26. Hellandsig, E.T. (1998). motivational predictors of high performance and discontinuation in different types of sports among talented teenage athletes. international journal of sport psychology, 29: 27-44. http://www.sciepub.com/reference/15780.

27. Strauss RS. Childhood obesity and self-esteem. *Pediatrics*. 2000;105(1).

28. Forhan M, Gill SV. Obesity, functional mobility and quality of life. *Best practice & research. Clinical endocrinology & metabolism*. 2013;27(2):129-137.

29. Stankov I, Olds T, Cargo M. Overweight and obese adolescents: What turns them off physical activity? *International Journal of Behavioral Nutrition and Physical Activity*. 2012;9.

30. Lambrick D, Westrupp N, Kaufmann S, Stoner L, Faulkner J. The effectiveness of a high-intensity games intervention on improving indices of health in young children. *Journal of Sports Sciences*. 2016;34(3):190-198.

31. About child & teen BMI | healthy weight, nutrition, and physical activity | CDC. https://www.cdc.gov/healthyweight/assessing/bmi/childrens_bmi/about_childrens_bmi.html.

32. Moore JB, Yin Z, Hanes J, Duda J, Gutin B, Barbeau P. Measuring enjoyment of physical activity in children: Validation of the physical activity enjoyment scale. *Journal of applied sport psychology*. 2009;21(S1):116-129.

33. Carraro A, Young MC, Robazza C. A contribution to the validation of the physical activity enjoyment scale in an italian sample. *Social Behavior and Personality*. 2008;36(7):911-918.

34. Haddad M, Stylianides G, Djaoui L, Dellal A, Chamari K. Session-RPE method for training load monitoring: Validity, ecological usefulness, and influencing factors. *Frontiers in Neuroscience*. 2017;11(NOV):612.

35. Kasai D, Parfitt G, Tarca B, Eston R, Tsiros MD. The use of ratings of perceived exertion in children and adolescents: A scoping review. *Sports Medicine*. 2021;51(1):33-50.

36. Eston R. Use of ratings of perceived exertion in sports. *International journal of sports physiology and performance*. 2012;7(2):175-182.

37. Tanaka H, Monahan KD, Seals DR. Age-predicted maximal heart rate revisited. *Journal of the American College of Cardiology*. 2001;37(1):153-156.

38. Chung AE, Skinner AC, Steiner MJ, Perrin EM. Physical activity and BMI in a nationally representative sample of children and adolescents. *Clinical Pediatrics*. 2012;51(2):122.

39. Murphy A, Kist C, Gier AJ, Edwards NM, Gao Z, Siegel RM. The feasibility of high-intensity interval exercise in obese adolescents: *http://dx.doi.org/10.1177/0009922814528038*. 2014;54(1):87-90.

40. Sebire SJ, Jago R, Fox KR, Edwards MJ, Thompson JL. Testing a self-determination theory model of children's physical activity motivation: A cross-sectional study. *The international journal of behavioral nutrition and physical activity*. 2013;10.
41. Sallis JF, Prochaska JJ, Taylor WC. A review of correlates of physical activity of children and adolescents. *Medicine and science in sports and exercise*. 2000;32(5):963-975.
42. Jones RA, Warren JM, Okely AD, et al. Process evaluation of the hunter illawarra kids challenge using parent support study: A multisite randomized controlled trial for the management of child obesity. *Health Promotion Practice*. 2010;11(6):917-927.
43. De Miguel-Etayo P, Muro C, Santabárbara J, et al. Behavioral predictors of attrition in adolescents participating in a multidisciplinary obesity treatment program: EVASYON study. *International journal of obesity (2005)*. 2016;40(1):84-87.
44. Nielsen G, Wikman JM, Jensen CJ, Schmidt JF, Gliemann L, Andersen TR. Health promotion: The impact of beliefs of health benefits, social relations and enjoyment on exercise continuation. *Scandinavian Journal of Medicine & Science in Sports*. 2014;24(SUPPL.1):66-75.
45. Mäkinen M, Puukko-Viertomies LR, Lindberg N, Siimes MA, Aalberg V. Body dissatisfaction and body mass in girls and boys transitioning from early to mid-adolescence: Additional role of self-esteem and eating habits. *BMC Psychiatry*. 2012;12(1):1-8.
46. Borg G. Borg's perceived exertion and pain scales. Human kinetics Website. https://psycnet.apa.org/record/1998-07179-000. Updated 1998.