Original Paper

Title: The Impact of Exercise Intensity Feedback via Technology for Children during Active Play

Madison Blake\textsuperscript{1}, BSc Kin; Martin Sénéchal\textsuperscript{1}, PhD; Megan Comeau\textsuperscript{1}, BSc Kin; Spencer Smith\textsuperscript{1}, BSc Kin; Danielle R Bouchard\textsuperscript{1}, PhD

\textsuperscript{1}University of New Brunswick, Fredericton NB, Canada

Cardio-metabolic Exercise & Lifestyle Laboratory Fredericton, New Brunswick, Canada, Faculty of Kinesiology, University of New Brunswick, Fredericton, New Brunswick, Canada.

Corresponding Author

Danielle R. Bouchard, PhD, CEP
Assistant Professor
2 Peter Kelly Drive
Faculty of Kinesiology, office 206B
University of New Brunswick
P.O. Box 4400
Fredericton NB
E3B 5A3
Phone: 506-443-3908
Fax: 506-443-3511
Email: dbouchal@unb.ca
ABSTRACT

Background: Most children do not engage in enough exercise at the recommended intensity. Using technological devices might increase the time children spend at greater intensities while exercising.

Objective: To determine if children receiving instant feedback of their exercise intensity, via technology, would spend more time in moderate-vigorous intensity (≥70% of maximum capacity) during active play sessions. We also aimed to explore if the children’s physical characteristics were associated with the average percentage of maximal HR reached during sessions.

Methods: Twenty children aged 5 to 11 years received feedback for two random sessions and did not for the other two out of 15 possible active play sessions. When receiving feedback, color-coded intensity based on heart rate (HR) was projected onto a wall; green corresponded to moderate intensity (≥70% of max HR) and red corresponded to a HR below moderate intensity. Age, anthropometric measures, muscle strength, body composition, physical activity level and fitness level were measured.

Results: The average percentage of maximal HR during a session was not different when having feedback or not (70.7 ± 6.4% vs. 71.1 ± 4.1%; P=0.93). No personal characteristics were associated with the average intensity recorded during the exercise sessions.

Conclusions: Receiving instant exercise intensity feedback is not associated with a greater proportion of time spent at moderate intensity or above in children aged 5 to 11 years when involved in an active play program. Personal characteristics are not associated with the intensity recorded when participating in an active play program.
Keywords: Biofeedback, exercise intensity, physical activity
INTRODUCTION

Moderate intensity exercise is often defined based on a percentage of estimated maximum heart rate (HR) (220-age); ranging from 50 to 70% [1]. Polar Canada, characterizes moderate-vigorous intensity as 70% or greater of an individual’s maximum HR (220-age) [2]. Physical activity performed at moderate-to-vigorous intensity is associated with a lower risk of obesity, high cholesterol, hypertension, and metabolic syndrome in children [3]. A small proportion of Canadian children are meeting the World Health Organization physical activity guidelines, that recommend 60 minutes per day of moderate-to-vigorous intensity physical activity [4]. Even when involved in organized activities, children can spend as little as 30% of the time in moderate intensity or above during a typical extracurricular session, therefore, are often not reaching the physical activity guidelines throughout the week [5].

Being able to monitor one’s intensity via technology could potentially motivate children to stay within the most beneficial intensities [6]. A whole body of evidence suggests that children are stimulated by technologies and in turn, are spending immense amounts of time using technology [7], [8]. Children ages 8-10 spend approximately eight hours per day using technology [9]. Health tracking devices have become more prevalent in society, even for children [10]. These devices provide feedback when performing physical activities and may increase participant’s motivation [11]. For example, studies have shown when adolescents have constant access to physical activity trackers, their running distance, energy expenditure, and time spent in moderate to vigorous intensity increases [10], [11]. However, to the best of our knowledge, only one study used a similar technology of instant feedbacks to increase time spent at moderate intensity or
greater [12]. The study was conducted in Australia and had children aged 11 to 13 wear a HR monitor during their physical education classes. One group of children had constant access to feedback for five weeks via a Polar HR watch and the control group did not. After each class, the children were asked to estimate how many minutes they spent in moderate to vigorous intensity and both groups were unable to adequately estimate the number of minutes, showing that intensity perception is a difficult concept for children to understand[1], [10], [12].

The main objective of this study was to determine if children, as young as age five would perform at moderate intensity or above for a longer period of time when receiving feedback of their intensity via a color-coded projection on the wall compared to children not having feed-back in the same session. We also aimed to explore if children’s physical characteristics were associated with the average percentage of maximal HR reached during sessions.
METHODS

Children between the ages of 5 and 11 were recruited through a local active play program lasting 12 weeks, in which children engaged in 60 minutes of physical activity per session for two evening per week. Active play is defined as a form of gross motor or total body movement in which young children exert energy in a freely chosen, fun and unstructured manner [13]. The current program was designed to engage children in the simple pleasures and benefits of regular physical activity, with a variety of fun interactive and non-competitive physical activities intended to foster self-esteem, confidence, a positive self-image and the joy of being physically active. Parents signed an assent form before the study began. The project was approved by the Research Ethics Board.

Descriptive Characteristics

Anthropometrics measures and grip strength were collected to describe the sample of participants according to the Canadian Society of Exercise Physiology Protocol. These were obtained during one of the sessions when the participant’s were not wearing any equipment. Height was obtained and body weight was measured to the nearest 0.1 kg on a calibrated column scale (SECA model #213, Hamburg, Germany). Waist circumference was taken with an anthropometric tape and measured to the nearest 0.5 cm at the upper lateral border of the iliac crest after the participant had crossed their arms over their chest [14]. Grip strength was measured with a hand dynamometer, the participant held the grip between their fingers and the base of their thumb, two trials were done on each hand and the highest score of all trials was entered and analyzed.
Participants’ body compositions were estimated using the Bod Pod (Cosmed, Concord, California, USA.). The Bod Pod was calibrated following standard protocol [15]. The participants wore minimal clothing and a bathing cap while sitting still in the Bod Pod. The thoracic gas volume was estimated. Then, the Brozek equation was used to estimate fat mass and muscle mass.

Cardiorespiratory fitness was estimated using the 20-meter shuttle test [16]. As per protocol, children ran between two lines 20 meters apart; reaching the line before the sound of a beep. Every minute the participants needed to increase their speed by 0.5 km/h [16]. The children were first given a warning when they did not reach the line on time and eliminated after the second consecutive time. Cardiorespiratory fitness was estimated using a published equation developed for this population [17].

Finally, participants were asked to wear a pedometer (SC-StepRx, Ontario Canada) for seven days to capture steps per day and time spent in moderate-vigorous intensity. Intensity was estimated based on cadence thresholds; 110 for moderate and 130 for vigorous [18]. Children were given the pedometers on the Tuesday or Thursday after the exercise session and were asked to give it back after the session on the following week. Therefore, the information included sessions in the program. A minimum of four days of wear time was required to be included in the analysis.

**Intensity During Sessions**

Participants were asked to wear a HR monitor, attached around their chest, for four sessions out of the 15 sessions offered. However, they only received feedback for two of the four sessions where they wore equipment. The feedback or no feedback sessions
were randomly selected using the select case function in SPSS. Before every session, the research assistant would open an envelope identifying which participants were selected to wear a hear rate monitor. If a participant missed a session, the randomization was postponed for the next session. For the two sessions where participants received feedback, their HR was displayed on a wall in the gym. Each child was associated with a number, and their goal was to maintain their HR at moderate intensity (≥70% of HRmax [19]) as indicated by displaying the number in green. Displaying the number in red indicated their HR was below moderate intensity. The number of each participant was not shared with the group. For the other two sessions, as mentioned previously, the participants wore the equipment, but did not receive feed-back.

Statistics

Because of the small sample size, non-parametric tests were used. Non-parametric Mann Whitney tests were done between the children’s average percentage of maximal HR while having feed-back and the children’s average percentage of maximal HR while not receiving feed-back for each session. Spearman’s correlations between the individual’s average percentage of maximal HR during all four sessions and participant’s characteristics were computed.
RESULTS

Participants’ characteristics are shown in Table 1. The median age was seven years old, with slightly fewer boys than girls (45%) participating in the study. The median daily steps per day was 12,051 steps per day and 276.6 minutes in that week was spent in moderate to vigorous intensity.

Table 1. Children’s characteristics

<table>
<thead>
<tr>
<th></th>
<th>N= 20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>7.0 (6.0-8.0)</td>
</tr>
<tr>
<td>Sex (boys)</td>
<td>9 (45.0 %)</td>
</tr>
<tr>
<td>Estimated VO(<em>2)(</em>{max}) (ml/kg/min)</td>
<td>44.4 (43.5-48.0)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>130.0 (127.0-133.5)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>25.9 (24.5-33.8)</td>
</tr>
<tr>
<td>Waist Circumference (cm)</td>
<td>61.0 (56.0-67.5)</td>
</tr>
<tr>
<td>Grip Strength (kg)</td>
<td>11.0 (8.0-13.0)</td>
</tr>
<tr>
<td>Fat Mass (%)</td>
<td>21.6 (16.7-27.7)</td>
</tr>
<tr>
<td>Average Daily Steps</td>
<td>12,051 (9,649-15,106)</td>
</tr>
<tr>
<td>Weekly MVPA (Minutes)</td>
<td>276.6 (197.4-356.1)</td>
</tr>
</tbody>
</table>

As shown in Figure 1, no significant difference (P=0.93) between the average percentage of maximal HR of the participants who received feedback and the average percentage of maximal HR of participants who did not receive feedback during sessions was recorded. Non-parametric independent t-tests were used to determine that there was no significant difference (p>0.05) between the feedback and non-feedback group for all 15 sessions. The median percentage of HR max during all sessions was 71% and 13 of the 20 children had an average of 70% of their HR max for all sessions.
The median proportion of time spent in moderate to vigorous intensity during the recorded sessions was 20.5 minutes, representing an average of 55.5% per session (Figure 2).
As shown in Table 2, there were no significant differences ($P>0.05$) between the participants’ average % of maximal HR and the measured participants’ characteristics.

**Table 2. Correlation between HR max % and Childrens’ characteristics**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>r</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.27</td>
<td>0.26</td>
</tr>
<tr>
<td>Weight</td>
<td>0.19</td>
<td>0.44</td>
</tr>
<tr>
<td>Height</td>
<td>0.30</td>
<td>0.21</td>
</tr>
<tr>
<td>Waist circumference</td>
<td>0.06</td>
<td>0.82</td>
</tr>
<tr>
<td>Grip Strength</td>
<td>0.06</td>
<td>0.82</td>
</tr>
<tr>
<td>Fat mass %</td>
<td>-0.02</td>
<td>0.93</td>
</tr>
<tr>
<td>Physical Activity Level</td>
<td>-0.18</td>
<td>0.59</td>
</tr>
<tr>
<td>Fitness Level</td>
<td>-0.09</td>
<td>0.69</td>
</tr>
</tbody>
</table>

Data are presented as r (p value) based on Spearman’s correlation
Discussion

The main objective of this study was to determine if children, as young as five years of age would spend more time at moderate to vigorous intensity when receiving feed-back of their intensity via a color-coded heart rate (HR) projected onto a wall compared to children not receiving feedback in the same session. Although, 55.5% of the time was spent at moderate intensity or above, the present findings indicate that when young children are receiving instant feedback during active play they were not spending more time in MVPA compared to those who are not receiving feed-back. We also aimed to explore if children’s physical characteristics were associated with the average percentage of maximal HR reached during the sessions. The participants’ characteristics were not significantly associated with average percentage of maximal HR they reached during the four monitored active play sessions.

The ability to identify exercise intensity is a complex task for anyone including children [12], [20], [21]. The median age of the participants involved in this study was seven years old. Their age may have contributed to their inability to perceive the intensity as previous research has suggested that children do not develop the ability to logically interpret surrounding stimuli, until 11 years of age [12], [22]. Therefore, it is possible that children involved in this study did not have the cognitive ability to interpret and respond to feed-back related to the exercise intensity. A study reported that the Procheska’s stages of change was influencing the ability to be receptive to feed-back and do more activity at moderate intensity with adolescents when in the stage of action[10]. The participants’ stage of change in the current study is unknown and should have been asked to the children and/or their parents. The children in this study were also quite active
based on their daily step count, averaging more than 12,000 steps per day. It is possible that different results would have been observed in a curriculum instead of during an after school program that tend to attract active kids [5]. Even if feed-back was not associated with greater intensity, it is important to note that 55.5% of the sessions were spent at moderate or vigorous intensity. This is important because most traditional physical education classes report that the average is only 39.4% for boys and 29.1% for girls in physical education classes [23]. Further, studies have shown that young children enjoy physical activity more when the activity is non-competitive and there is choice involved compared to structured activities [24]. Potentially enjoyment contributed to the children reaching an average of 70% of their maximal HR regardless of if they were receiving feedback.

Of the characteristics that were measured, none of them were associated with the average percentage of maximal HR reached during sessions, regardless of feed-back or not. In terms of body weight it seems that intensity was not influencing the reached intensity during sessions when doing active play. This result is similar to a study conducted with children aged between six and nine years old that found that non-obese and children living with obesity had similar heart rates during active play sessions [1]. Prior research showed that children living with obesity perceive themselves to be less competent than their peers, and would feel more comfortable engaging in active play than in a structured athletic setting [1].

Children are often more active during physical education classes if they have a high ability levels and low BMI’s [23]. Since the participants’ physical characteristics did not
affect the children’s average intensity, perhaps active play should be encouraged in different settings to increase fitness level.

There were some limitations to this study; firstly there was a small sample size. The children were also young, considered active and were voluntarily attending the program. While, the Kin Kids sessions were an hour in length, the children’s heart rates were only recorded for an average of 37±3.9 minutes. The sample was not randomized and a cross over design was not used. Each session was different, meaning, the children did not necessarily engage in the same activities when they had or did not have feed-back. The children receiving feedback were not isolated from the children not receiving feedback. Therefore, the children not receiving feed-back may have been mirroring the intensity of the children who were receiving feed-back. However, physical activity was objectively measured using blinded pedometers. The colour-coded projection on the wall was novel for the children and the active play program allowed for a well supervised physical activity intervention.

In summary, providing children with an average age of 7 years, instant feed-back about their intensity does not significantly increase their intensity when engaging in an active play session. However, it is important to note that during the active play sessions, children spent 55.5% of the time at moderate to vigorous intensity. Further research should examine the effects of providing feed-back on exercise intensity when performing active play with older children with a broader range of physical activity levels.

Conflicts of Interest
None declared.
References


