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# A pilot study of children's physical activity levels during imagination-based mobile games

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**Abstract**

This research looked at Biba: a suite of mobile games intended to get kids back out to playgrounds and engaging in more moderate to vigorous physical activity (MVPA). Year after year, annual national surveys report a general decline in physical activity amongst children and a corresponding increase in screen time. Further to this, time spent outside by children has been reported to be on the decline since the 1980s. Recent work has suggested that in order to 'maintain the outdoor recreation participation of children across America, park and recreation professionals may need to embrace the expanding role of technology'. This research tested Biba in precisely this regard, deploying a 20-subject within-subject experimental design that compared Biba playground game-play with typical free play playground sessions, measuring heart rate activity in them. The outcome demonstrated that Biba playground play results in greater amounts of MVPA with a difference in heart rate that was significantly higher in the Biba play session than in the free play session $t(19) = 2.41$, $p < 0.05$.

**Keywords**

Exergaming, fitness, games, MVPA, playground

## Introduction

Moderate to vigorous physical activity or 'MVPA' is defined by the World Health Organization as a combination of two forms of activity: moderate intensity activity, which 'requires a moderate

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amount of effort and noticeably accelerates the heart rate', and vigorous intensity activity which 'requires a large amount of effort and causes rapid breathing and a substantial increase in heart rate' (World Health Organization, 2016). Recent research findings suggest that the daily MVPA of children is on the decline (ParticipACTION,2016). There is also evidence that children are increasingly engaged in screen time and that high levels of time spent engaged in screen-based activity is associated with obesity (Duncan et al., 2012).

Touchscreens are frequently blamed and children's attentional economies are largely dictated by the ephemerality of screen-based devices (De Castell and Jenson, 2004). ParticipACTION's 2016 annual physical activity report card for children and youth reports that 76% of 5- to 11-year-olds are getting more than the recommended limit of 2 hours of screen time a day (ParticipACTION, 2016). Perhaps even more telling are the self-reports of children who claim as much as 7 hours and 48 minutes of screen time per day (Leatherdale and Ahmed, 2011). These screen time statistics are coupled with the reports of decreased outdoor physical time, as only 14% of 5- to 11-year-olds are getting the recommended amount of 60 minutes of moderate to vigorous activity a day (ParticipACTION, 2016).

Given the ubiquity of screen-based devices in our culture and the increased screen time trend in our children, we asked the question, how can we use technology-based tools to engage children in MVPA? In the wake of 'active' video game technologies such as Nintendo's Wii and the remarkably successful Pokemon Go, we endeavoured to employ the motivating effect of screen-based devices to achieve the objective of increasing the activity level of children who use them, and we did so by testing a suite of mobile games designed to get kids off the couch and participating in greater amounts of MVPA on the playground (Althoff et al., 2016). These games leverage the use of imagination by presenting fictional scenarios that prompt instances of active play on the playground, upheld by the phone in unique ways.

## Motivating MVPA

How do we determine how best to design mobile games that promote MVPA? One factor that has been positively correlated with MVPA in children consistently across studies is self-efficacy (see Bungum et al., 2000; Ryan and Dzewaltowski, 2002). Self-efficacy is, essentially, an individual's belief about their ability to influence the events that affect their lives: what we might generally refer to as agency (Bandura, 1993).

Given that this sense of agency is consistently linked to MVPA in contemporary literature around children's activity (Trost et al., 1999), any game designed to increase MVPA ought to facilitate a wide range of possible interactions, so that a child interacting with this game will have the best possible chance of feeling engaged, making contributions and seeing success from those contributions. This, of course, highlights an obvious problem with traditional exercise-based, fitness-focused activities. While the top-down goal of an exercise-focused activity is to increase MVPA, this goal alone often places fitness as an extrinsic objective of an obligatory task.

An important insight from fitness research, specifically, educational design, is the concept of 'stealth learning' (Cordova and Lepper, 1996). Stealth learning is thought to occur when a player is doing something critical to a game experience that is integrally linked to the learning (i.e., learning by doing in a natural context) and there is an intrinsically rewarding experience that follows (Gee, 2003; Greene & Lepper, 1974; Lepper et al., 1973). Borrowing a 'games-for-learning' approach from educational games when applied to physical play, we propose the notion of *incidental activity*: The idea of participating as a physical player agent in a game that tacitly asks for

commitment to, and mastery of, one's physical body in a given scenario. That is to say, one participates in fitness because one's chosen game activity intuitively calls for it, or rather, the activity promotes an inherent sense of agency.

In their 2005 paper, Burette and Whitaker make several recommendations for motivating physical activity in children by moving away from the traditional focus on health and physical well-being and instead of focusing on mental well-being and enjoyment. In congruence with the concept of incidental activity, they suggest that imaginative and/or improvisational play be given high priority with children. Thus, understanding how to design forintrinsically rewarding, imaginative gameplay canafford opportunities for incidental activity; fostering higher agency situations that can theoretically increase the likelihood of continued participation in MVPA.

Another important correlate of MVPA in children is parental involvement (Zerger et al., 2016). Social support, especially from parents, is yet another factor that is consistently linked with higher levels of MVPA in children and correlations have been reported between physical activity and parental involvement (Baskin et al., 2013). When adult attention is made contingent on active playground activities (such as running, jumping, and climbing), high levels of MVPA are observed, illustrating how MVPA can be promoted through parental engagement (Zerger et al., 2016).

A strictly aerobic exercise-based intervention may be a poor choice, given the importance of parental involvement and boosting child self-efficacy, but the real benefit of a play-based game is the interactive nature of gameplay. By 'interactive play' we specifically mean that both a parent (or other adult in a similar role) and a child are active and dynamic participants in the game. While we discussed the benefits of parental attitude and attention above (Zerger et al., 2016), actual active parental participation has been shown to be more effective than just encouragement and attention (Larson et al., 2014). Therefore, one would want to design a game that included caretakers as genuine co-participants.

Screen-based games designed to increase physical activity are not a new concept. A review of studies on computer or web-based interventions found that most had significant positive impacts on health and physical activity (Hamel et al., 2011). However, the effects of many of the computer-based interventions were short-lived and did not show effectiveness over the long-term. Researchers recommend increasing parental involvement in achieving this aim, and this is precisely what Biba, the suite of games we tested in this study, looks to achieve in contributing to replay and longevity.

## What are Biba games?

Intended to be played by parents and children together on mobile devices, Biba is a collection of games for iOS and Android that expressly seeks to reorient the screen-literacy of today's child towards active, physical play for boys and girls aged 3–9 years.

A Biba game takes place on the playground and involves a parent holding their phone with a game open and issuing playful directives that the child is to follow based on the imaginary premise presented. The child spends most of their session time playing away from the phone on playground equipment based on the game directives. The child returns to the phone intermittently to perform a game function, completes a mini-game or advances their progress through the game's imaginary scenario (see Figure 1 for an example). For example, if a child is in a car in 'Biba Drive!', they're completing laps and stopping for repairs at their parents phone to perform a 'pit stop'. It is an

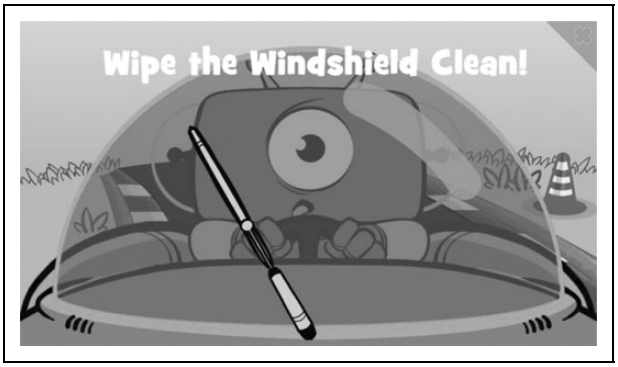


**Figure 1.** An Image from one of Biba Drive's pit stop mini-games.

explicit goal of Biba games to encourage physical play (i.e. MVPA) while discouraging screen fixation. Biba is designed to get kids playing *through* the phone, rather than *on* it.

In addressing MVPA, what is perhaps Biba's most fundamental principle is encouraging kids to use their bodies to enact or participate in Biba games and not simply sit on a bench and passively move their progress forward through an avatar. In Biba games, children effectively take on the role of the avatar with parents getting involved using the readily accessible digital device they already carry with them.

## The present study

The present study, conducted through a partnership of a Simon Fraser University researcher and child psychologist and the Biba user research team, was designed as a pilot test of the effectiveness of the Biba game system's in promoting MVPA. Specifically, the study was designed to evaluate levels of MVPA during time spent playing Biba and how they compared to MVPA during typical playground play. It is predicted based on the extant literature that children will engage in higher levels of MVPA during time spent playing Biba, as compared to time spent in normal playground activity.

## Methods

### *Participants*

Child participants were 11 female and 9 male children between the ages of 4 years and 11 years, with an average age of seven years (SD = 1.75). Children participated in conjunction with a parent or another guardian such as an aunt or grandparent participating with consent on the parent's behalf. Accompanying adults comprised 12 females and 9 males. This resulted in 15 same-gender child/adult participant pairs and 5 differing gender pairs. Child height and weight were recorded, and body mass index (BMI) was calculated for all participants. BMI ranged between 13.12 and 20.54 $kg/m^2$, with an average of 15.62 $kg/m^2$ (SD = 2.1). All but three children participated as a group of two to three siblings. Participants were recruited through their parents via word of mouth and recruitment advertisement. Informed consent was provided by parents for both themselves and their participating children. Participation was compensated with parent and child day passes to

Telus Science World (valued at approximately $CAD50). Child participants reported engaging in high energy activities such as sports, dance or games on average of 3.2 (SD = 2.03) times during the previous weekend and reported doing highly active physical things in their free time an average of 4.1 (SD = 1.72) times during the last seven days.

## Location and materials

Research sessions occurred at various playground sites in the greater Vancouver, British Columbia area. Sites were selected based on convenience of the participants, availability of equipment and density of playground traffic. To be eligible, a playground needed to have at least four of the following six types of playground equipment: climber, swings, tube, slide, bridge and bars/overhang. Sessions occurred only during times when playground traffic was low enough to ensure that child participants had a selection of equipment available to them without the need to wait for other children to vacate. A short demographic survey was provided to parents, which contained information about the child's characteristics, as well as their participation in physical activities in the past seven days. During testing, child participants wore FitBit activity monitors to track the heart rate. Biba play was conducted using an iPhone 6 Plus or Blu XL Android Phone (both the same 5.5" screen resolution).

## Procedure

After participants were fitted with the heart rate monitors, a baseline reading of resting heart rate was taken before the start of the session. Following this, participants engaged in one of two session orders. Eleven participants first engaged in a 'free play' session. During this session, child participants were instructed to play on the playground as they would normally. Children participating as pairs or triads generally stayed together and played as a group. Parents (or surrogates) were not given specific instructions for their level of interaction with their children during this time and were permitted to interact as much or little as they wished, in an effort to replicate what a typical period of playground activity would look like. Some parents were highly involved in their children's playground activities, creating games or assisting children with the use of playground equipment (pushing on swings, etc.), some were present and attentive but not physically involved, while others were largely uninvolved, remaining some distance away or talking to other adults present. This free play session ran for approximately 20 minutes, with heart rate data being collected every five minutes. After 20 minutes, participants were instructed to take a short break. Breaks lasted between 10 and 15 minutes. During the break, participants were asked to sit and rest or walk slowly. A small snack or drink was suggested as an option during the break, though not all participants chose to do so. Heart rate was checked every five minutes during the break. Once participants were rested following the break, the Biba play session was initiated. Biba play sessions were directed by a 35-year-old male researcher familiar with the Biba games in order to control for varying levels of technical proficiency among parents and caregivers. Participants played three to four different Biba games over the course of 20 minutes. All of the Biba games had a similar structure that involved the researcher (acting in place of a parent) holding a mobile device that acted as a checkpoint within the framework of a given game. Children's role in playing the game varied based on the game selected and its theme (butterfly collector, archaeologist, etc.) but generally involved the child receiving a game objective to use one or more pieces of playground equipment, then returning to the device to complete a mini-game or fulfil an objective on the

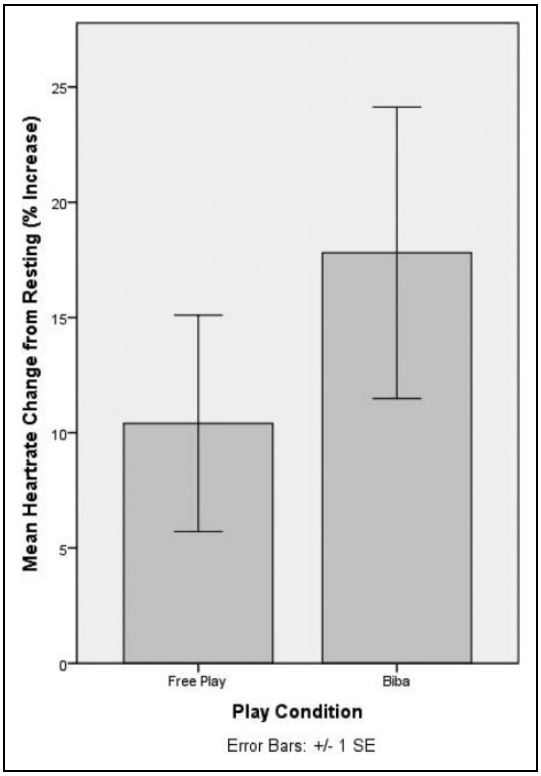


**Figure 2.** Mean heart-rate change from resting: free play vs. Biba play conditions.

device, repeated several times. Children participating as a group either alternated turns during Biba games or played as a team, depending on the preference of the participants. Heart rate was collected approximately every five minutes during the Biba session. The remaining 9 participants followed the same play and testing patterns, except with the order of the Biba play and free play sessions reversed (note: there is a slight imbalance in numbers in the two conditions due to the varying group sizes of one, two, or three participants per session).

## Results

Average heart rate was calculated for each participant of both the free play and Biba play sessions. These averages were then used to calculate a percentage change from resting heart rate for both sessions for each participant (see in Figure 2). Average resting heart rate was 98.7 bpm (SD = 13.6). Average heart rate change was +10.4% (SD = 21.0) for the free play session, and +17.8% (SD = 28.3) for the Biba play session. A paired samples $t$ test showed that the difference in heart rate was significantly higher in the Biba play session than in the free play session $t(19) = 2.37$, $p < 0.05$, $d = 0.53$.

To check for potentially confounding interactions, the change in heart rate between the free play and Biba sessions was calculated and a univariate analysis of variance (ANOVA) was performed for the change in heart rate between the free play and Biba play sessions, with age, gender and BMI

as covariates and session order as a fixed factor. The ANOVA revealed no significant effects of age, gender, BMI or session order (all $F$s > 1). It should be noted, however, that due to the small sample size of this project, only very large effects would likely be revealed in this analysis.

These results are in keeping with our prediction: MVPA (as estimated from heart-rate) was higher during the Biba play session than in the free play session. Furthermore, this effect does not seem to be a result of the order of the play sessions, nor related to any participant demographic.

## Discussion

The objective of the present work was to establish whether a mobile device–based game – in this case the Biba suite of games – could be more effective in promoting MVPA during playground play in young children than unstructured, free play. The results of the experiment support this hypothesis, with participants showing higher heart rate during Biba play sessions than during free play sessions. It is assumed that the recorded difference in heart rate is due to the more moderate to vigorous and active play activities promoted by the games. This assumption is also in keeping with qualitative observations by researchers of participant behaviour during play sessions, where participants were noted in our research logs to more often be moving hastily or vigorously during Biba play sessions than during free play.

It should be noted that the active participation and attention of an adult during the Biba sessions were also observed to be relevant factors, which aligns with the literature reviewed above. There was a noticeable increase in enthusiasm, engagement and what would certainly qualify as MVPA during parent-/adult-mediated playground play, and this phenomenon not only held for Biba sessions but was also observed in some cases where free play was conducted with a parent or adult. The mediating and attentive role of an adult and/or caregiver should not be disregarded here. Creating an active role for an adult caretaker as a part of playground play is a core feature of the Biba system and was expected to encourage active participation from the child.

Regarding the interactive element of Biba, our observational notes point to participants tending to be more focused and attentive under the Biba condition, with a number of sessions even requiring kids to be reminded multiple times to end a session despite their enthusiasm. Children seemed to enjoy the agency involved with directing the minutiae of gameplay and the novelty of the screen interaction (e.g. unearthing bones buried in Dino Dig or helping carry a Biblet back to the device in Collectobots and actually ‘dropping’ it into the device). That said, it should also be acknowledged that, long-term, the novelty aspect of some games could diminish and this would likely require a combination of a continuing variety of titles and/or a graduated design for children to promote some sense of investment in gameplay over the long-term.

### *Limitations of the present work*

Despite the promising implications of this experiment, there are some notable limitations to this study, stemming from the limited budget and scope,which should be duly addressed and considered in evaluating the results. This study was conducted with a relatively small sample size. Although the count of 20 participants was sufficient to demonstrate the difference between the two conditions of interest, this may not have been sufficient to illustrate an important interaction, for instance, that the Biba games may have been more effective for older participants. Additionally, to eliminate the possibility of participant attrition, participants completed both experimental conditions in the same session, leading to an increased possibility that one condition may have affected

the other. Moreover, to avoid the need to train parents in the use of the game and control for parental familiarity with mobile devices, researchers conducted the Biba play sessions, leading to the possibility that the observed results were influenced by the adult participant (e.g., parent or a researcher). It is possible, for example, that a parent may have provided subtle cues to 'perform well' for the researcher-led portion of the study, as a result, seeing kids behave more actively during the Biba testing condition.

We acknowledged the potential for researcher bias at the outset. To reduce the potential for bias on the part of the Biba team, this study was designed and conducted in collaboration with a Simon Fraser University researcher who is also a practicing child psychologist. We made every effort in this partnership to enhance the rigor of the work and temper any partiality in our interpretations of the results.

### *Implications*

While small in scope, the results of this study are nonetheless important in considering the problem of how to increase MVPA in young children. At the most basic level, the results of this study support the ideas discussed earlier that the most effective games for increasing MVPA in young children will be interactive and play based. Moreover, this study lends evidence to the possibility of effective *digital*, *screen-based* interventions, despite the common contention that digital screens are part of the problem, rather than the solution.

Furthermore, this study supports Biba specifically as an MVPA promoting game. The positive results of this study will help inform the development of this software over time, improving its effectiveness.

### *Future research*

The most obvious direction for future research in this area is to expand the scope of the study into a fully realized longitudinal project. Such a study would include a larger sample size and would involve parents incorporating the Biba software into their normal, everyday play patterns of their children, and examining whether the differences exhibited in the present work persisted over extended use and also whether MVPA patterns are similar when parents lead the activities. It would also be important to know whether the parent and child interest in using the software remained over time, whether Biba games successfully increase visits to the playground when introduced to the family household as an option for outdoor play and whether when children engage in the games their MVPA increases on the playground.

**Declaration of conflicting interests**

The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: Two of the three authors of this paper are employed by Biba and are the developer of the Biba Software which is employed as part of this research.

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