Physical Activity in Children:
Correlates and Scalable Intervention Strategies

by

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A dissertation submitted in partial fulfillment of

the requirements for the degree of

Doctor of Philosophy

(Department of Kinesiology)

at the

UNIVERSITY OF WISCONSIN-MADISON

2023

Date of final oral examination: 06/12/2023

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Acknowledgements

This dissertation would not have been possible without the significant contributions of numerous individuals, and it is with deep gratitude that I express my sincerest appreciation to those who have made this endeavor a reality. I would like to extend my deepest gratitude to my committee members, particularly Dr. Lisa Cadmus Bertram, who served as my PhD chair for the first 4.5 years of the program. Lisa, your trust in my abilities from the very beginning has been pivotal to my success. You granted me the freedom to explore my strengths while offering invaluable guidance that helped shape my research identity. Your expertise in epidemiology and profound insights into research questions have influenced my own approach to problem-solving. I am indebted to you not only for your exceptional mentorship but also for your flexibility and understanding, which played a crucial role in maintaining my mental well-being throughout this journey.

I would like to express my heartfelt appreciation to Dr. Luis Columna for graciously taking on the role of my current dissertation chair despite his demanding schedule. His consistent encouragement, guidance, and expertise throughout my PhD program have been invaluable to my academic growth. Additionally, I would like to acknowledge the invaluable contributions of my committee members: Dr. Kelly Koltyn, Dr. Kristen Malecki, Dr. Ron Gangnon, and Dr. Paul Peppard. Their dedication, mentorship, and unwavering commitment to my academic journey have been indispensable.

I am grateful also to the undergraduate research assistants at the Physical Activity Epidemiology lab, Marla, Greta, and Skylar, who played a crucial role in the recruitment and data collection for the ACTIWEB-PA study. My sincerest appreciation also to the researchers at SHOW for their tireless assistance in procuring data and patiently addressing my inquiries.

Additionally, I extend my deepest appreciation to the children and parents who participated in the ACTIWEB-PA study. Their commitment and participation were vital to the success of my research, and they deserve recognition as the true heroes of this study.

Lastly, but most importantly, I want to express my heartfelt gratitude to my family. I extend my deepest appreciation to my mother, Meenakshi, for always supporting me and more importantly being a true friend to me. In addition, I dedicate this dissertation to my late father, Praval, who I dearly miss. I know he would have been immensely proud of this achievement. Papa, this dissertation is a tribute to you, and I dedicate it with profound love and gratitude.

I reserve the most heartfelt acknowledgements for the two most important individuals in my family—my source of joy and pride, my son Vikrant, and my lifelong companion, my husband Vaibhav. Vikrant, you have played the most pivotal role in my PhD journey, keeping my spirits high even during the most challenging times. Your presence has reminded me of what truly matters in life, and every moment with you has been filled with joy. I am grateful for your patience and understanding as I shared my attention and time between you and "the other child," my PhD. Vaibhav, you have been my biggest supporter and a true partner in every respect. I am grateful for your encouragement in pushing me to pursue my academic goals after a long break when I doubted myself. Without you, I would not have had the strength to take on this challenging endeavor. I have yet to meet someone as invested in their spouse's career goals as you are, and this accomplishment belongs to both of us. Together, we have navigated two PhD journeys, raised a family, shared the highs and lows, and created cherished memories as student parents. Through it all, you have been my rock, providing unwavering support and stability as an exceptional parent, amazing partner, and an inspiring researcher. Here is to even more fulfilling academic journeys ahead for both of us.

Dissertation Abstract

Introduction. The growing population of children and adolescents with low physical activity levels and poor psychosocial health necessitates accessible interventions that promote well-being. Electronic health (eHealth) physical activity interventions are a promising choice due to their scalability and accessibility. This dissertation examined the feasibility and effects of ACTIWEB-PA, a remotely delivered, web-based movement integration program for children while also assessing the correlates of physical activity and sedentary behavior in youth, providing valuable insights for future intervention design.

Methods. Active Children through In-home Web-based Physical Activity (ACTIWEB-PA) pilot randomized controlled trial: Eighty-two insufficiently active children aged 8-11 years were randomized to either an exercise intervention group or a wait-list control group. The intervention was a 12-week-long, self-directed, remotely delivered web-based movement integration program offered through the UNICEF Kid Power website. Feasibility was assessed with recruitment, retention, and intervention adherence rates. Intervention satisfaction was assessed using surveys and qualitatively, with end-of-study interviews. Intervention effects on physical activity and psychosocial health outcomes were assessed using mixed models.
Survey of Health of Wisconsin (SHOW) data study: Data from 308, 6–17-year-olds with valid accelerometer wear time from wave II of SHOW were used to examine potential correlates of accelerometer measured physical activity and sedentary behavior. Mixed models were used to identify sociodemographic, anthropometric, neighborhood, screen-time, and parental factors associated with the outcomes.

Results. ACTIWEB-PA study: The mean age of participants was 9.2±1.1 years and 51.2% were female. A recruitment rate of 73.6% was obtained. Follow-up surveys were

completed by 93.9% participants (retention rate-1) and valid follow-up accelerometer wear was completed by 80.5% participants (retention rate-2). In addition, 69.4% had high program adherence in the exercise intervention group. Intervention was found to be appropriate, pragmatic, and enjoyable based on qualitative analysis. Suggestions to improve novelty, variety, and incorporating peer participation were made by families. Adjusting for baseline imbalances in outcomes, there were no significant intervention effects on the primary outcomes of physical activity. Among the secondary outcomes, only behavioral adjustment sub-scale of the Piers Harris Self-Concept scale saw significant positive improvements ($p = 0.03$). Our results were indicative of a gender-based variation in physical activity outcomes.

SHOW data study: Mixed model analyses showed non-significant but meaningful associations of minutes/day of moderate to vigorous physical activity (MVPA) with screen time ($p = 0.06$) and Walk Score ($p = 0.09$). In addition, BMI ($p = 0.04$) of the participant was significantly associated while gender ($p = 0.16$) was non-significantly associated with minutes/day of sedentary bouts.

Conclusion: The ACTIWEB-PA study was found to be feasible, and the movement integration program had high adherence rates and was deemed acceptable. The intervention did not impact children's physical activity and psychosocial health outcomes significantly. Nevertheless, given the increasing interest in and utilization of remotely delivered eHealth interventions to promote physical activity among children, this study offers valuable insights for optimizing future trials in this field. Important correlates of objectively measured MVPA and sedentary bouts in children and adolescents were also identified, including the modifiable screen time. These findings together advance the field of children's physical activity epidemiology and provide insights to inform the design of future interventions aimed at promoting physical activity and reducing sedentary behavior in children and adolescents.

Chapter 1 - Introduction

Physical activity is an important component of a healthy lifestyle for children, as it is associated with a multitude of physical, mental, and cognitive benefits (1). Regular exercise in children has been shown to improve cardiorespiratory and muscular fitness, thereby enhancing overall physical fitness and reducing the risk of cardiovascular diseases, such as heart disease and stroke, and musculoskeletal disorders, such as osteoporosis (1). In addition, physical activity is effective in reducing obesity among children, which in turn can decrease the risk of type-2 diabetes and certain types of cancer (1,2). Evidence also supports the positive effects of physical activity on cognitive function and brain health (3). Specifically, regular exercise has been linked to improvements in working memory, attention, cognitive flexibility, and academic performance (3,4). Moreover, a growing body of research has highlighted the potential benefits of physical activity on psychosocial health of children (5). Exercise has been shown to be effective in reducing symptoms of psychological ill-being, including depression, stress, and negative affect, while also enhancing psychological well-being, such as self-image, satisfaction with life, and happiness (6).

Despite the established benefits of physical activity, low achievement rates in children and adolescents remain a significant concern. Only 26.3% of 6–11-year-olds meet federal physical activity recommendations, with achievement rates dropping even further to 14.8% in adolescence (7). Concurrently, growing evidence of the potential psychosocial benefits of physical activity highlights the need for further research in this area, particularly given rising rates of poor mental health among children and adolescents in the United States (8). Recent mental health surveillance data indicate that approximately 9.4% (5.8 million) of children and adolescents have been diagnosed with anxiety, and 4.4% (2.7 million) with depression (8), with the Covid-19 pandemic further exacerbating psychosocial health issues in this population (9). This growing population of children and adolescents with clinical diagnoses are the “tip of the iceberg” – many others are not diagnosed, experience sub-clinical symptoms of anxiety or depression, or have low confidence and self-esteem (10). This highlights the urgent need for scalable, equitable, and accessible interventions to promote mental health and well-being in young people. In this context, physical activity interventions may offer a promising non-pharmacological approach. By offering opportunities for social engagement, stress reduction, and improved self-esteem, physical activity interventions may provide important psychosocial benefits that can help promote positive mental health outcomes in children and adolescents (11).

To realize the health-enhancing benefits of physical activity, traditional in-person programs, including school-based programs, have long been offered as a means of increasing physical activity among children and adolescents (12–14). More recently, electronic health (eHealth) interventions have emerged as an additional avenue to promote physical activity among young people (15). eHealth interventions, which are defined as "health services and information delivered or enhanced through the internet and related technologies" (16), have the potential to promote health equity by providing physical activity opportunities to children who may lack access to parks, sports clubs or teams, and after-school programs (17). Moreover, eHealth physical activity programs offer a safe, home-based alternative to traditional sports, which has become particularly relevant since the COVID-19 pandemic (18). While the pandemic has accelerated the use of eHealth programs, their adoption is expected to persist even after the pandemic has subsided, given the increasing penetration of "smart" screen-based devices and the rising prevalence of internet access in American homes (19–21).

While eHealth physical activity interventions hold promise as scalable and accessible approaches for improving children's health, the existing evidence supporting their effectiveness is limited. Existing eHealth physical activity interventions for children and adolescents encompass various modalities, including evidence-based knowledge articles accessed through websites or emails (22), mobile apps for goal setting, monitoring, and positive reinforcement of physical activity (23–25), social-media apps on mobile platforms for peer support (26,27), and digital console-based exergames or active video games (28–30). Preliminary findings from small-scale systematic reviews indicate that informative emails, smartphone-based interventions, and active video games may hold promise as strategies to promote physical activity among children (22,30,31).

Building on the potential of eHealth physical activity interventions, another approach gaining popularity in recent years is the utilization of web-based exercise video programs known as movement integration programs, which offer an innovative means of promoting physical activity among children (32). These programs typically feature energetic exercise and dance videos performed by models, allowing children to follow along using digital devices. They have been widely implemented in schools, providing children with regular movement breaks and active indoor recess (32,33). Furthermore, these programs have rapidly gained traction as a popular choice for promoting physical activity among children at home (34).

Despite the widespread acceptance of movement integration programs, their evaluation remains limited in scope. To date, only a few assessments have been conducted (35), predominantly relying on evidence from a single small non-randomized study carried out in a school setting with a sample size of only 16 participants (36). Additionally, two informal evaluations, conducted within school settings and lacking peer review, have contributed some insights to the field (37,38). Consequently, it is essential to acknowledge the current lack of rigorous investigation into the feasibility and effectiveness of movement integration programs for children in a home-based setting. Further research is therefore necessary to fill this gap in knowledge and gain a better understanding of the potential benefits of these programs in home environments. To address these research gaps, I conducted the Active Children through In-home Web-based Physical Activity (ACTIWEB-PA) pilot study as the first study in this dissertation. This study employed a rigorous randomized controlled design and an objective assessment of physical activity and sedentary behavior to investigate the feasibility and effectiveness of a novel, youth-targeted, remotely delivered, web-based movement integration intervention. The exercise sessions were self-directed, unsupervised, and took place at participant homes. The intervention utilized the UNICEF Kid Power website, a freely accessible platform that offers a range of dance, sport, and fitness videos specifically designed for children. By utilizing the UNICEF Kid Power website as a platform, the ACTIWEB-PA study aimed to examine the potential of eHealth interventions in promoting both physical activity and improvements in psychosocial health among children in a home environment.

Research focusing on the evaluation of remotely delivered physical activity eHealth interventions for children is essential for advancing our understanding of their feasibility, intervention satisfaction, and potential effects. However, to ensure the effectiveness of these interventions, it is imperative to gain a comprehensive understanding of the factors that influence children's physical activity levels. By identifying these determinants, future interventions can be designed and implemented to specifically target the factors and subgroups within the young population that require the most attention and support. This approach will enhance the precision and impact of physical activity interventions, ultimately promoting better health outcomes in children. To this end, a significant body of literature has extensively examined the determinants of physical activity in children and adolescents, identifying various factors that influence physical activity achievement (39–47). Additionally, a comprehensive review of reviews identified 16 correlates of physical activity in this population, including demographic, socioeconomic, neighborhood, family, and individual-level factors (44). These correlates encompass sex, age, ethnicity, parental education, family income, socioeconomic status, perceived competence, self-efficacy, goal orientation/motivation, perceived barriers, participation in community sports, parental support, support from significant others, access to sport and recreational facilities, and time spent outdoors (44). In addition to physical activity, several important predictors of sedentary behavior in children and adolescents have also been identified, although research in this area remains limited. These include, age, sex, paternal education, race/ethnicity, availability of neighborhood green spaces and walking infrastructure, parental screen time, and parental health and functioning (45,47–50).

Despite considerable progress in investigating the determinants of physical activity and sedentary behavior in children and adolescents, gaps in literature exist. One major gap is the limited use of direct measures, such as accelerometers, to assess these behaviors (43,49). Self-report measures commonly used in studies are susceptible to misclassification and recall bias, leading to unreliable results (51). While there has been a recent increase in the use of accelerometers in physical activity research in children and adolescents, it remains a relatively new development (52,53). To improve the validity and reliability of findings, rigorous measurement approaches utilizing accelerometers are recommended for both sedentary behavior and physical activity. Another gap in the evidence is that the existing studies frequently equate sedentary behavior with television viewing, disregarding the full range of screen time activities

(54,55). Children's screen time patterns have shifted in recent years, with TV viewing representing only a fraction of their overall digital screen usage (56). In addition, studies that do account for a broader range of screen time activities often fail to consider sedentary time spent in other seated activities, such as during transportation or engaging in indoor games or reading (57). Notably, research suggests that the correlates of screen time and overall sedentary behavior in children may differ (58). Thus, this omission of non-screen based sedentary time may lead to the exclusion of important factors associated with sedentary behavior in children and adolescents. Therefore, comprehensive measurement approaches that consider all forms of sedentary behavior, along with accelerometers, are needed to enhance the quality of evidence on the correlates of both sedentary behavior and physical activity in the young populations.

Thus, the second study in this dissertation aimed to overcome the limitations of the existing evidence by comprehensively examining potential correlates of accelerometer-measured physical activity and sedentary behavior in children and adolescents. Specifically, I investigated demographic, socioeconomic, screen-time, parental, and neighborhood factors that may potentially impact physical activity and sedentary behavior of this population, using data from wave II of Survey of Health of Wisconsin (SHOW). In brief, SHOW, which has been ongoing since 2008, enrolled a representative sample of non-institutionalized, civilian Wisconsin residents in an annual cross-sectional survey (59). Data collection for wave II took place from 2014 to 2016 and included information on demographics, socio-economic status, anthropometrics, physical and built environment, health history, health care, and health-related behaviors, among other variables (59).

In summary, the two studies conducted in this dissertation complemented each other and contributed to addressing research gaps concerning children's physical activity and psychosocial health. Project 2 aimed to identify specific population subgroups that require interventions to increase their physical activity levels and reduce sedentariness. This has important implications for developing tailored physical activity programs targeted towards these groups. On the other hand, project 1 examined the feasibility and impact of a web-based physical activity intervention on both physical activity levels and psychosocial health outcomes among children. By integrating the findings of these studies, this dissertation advances our understanding of physical activity in children and adolescents and the potential of scalable interventions to promote higher activity levels and psychosocial well-being in this population. As such, to fulfill the objectives of this dissertation, the following three aims have been identified, with each corresponding to a separate chapter designed as a manuscript.

Aim 1: ACTIWEB-PA study. To investigate the feasibility and intervention satisfaction of a remotely delivered, web-based movement integration program in children aged 8-11. It was hypothesized that the study would be feasible to implement based on study recruitment, retention, and adherence rates and that the participants would express high satisfaction with it.

Aim 2: ACTIWEB-PA study. To examine the intervention effects of a remotely delivered, web-based movement integration program on 8-11-year-old children's accelerometer measured physical activity, sedentary behavior, health-related quality of life, and Self-Concept. It was hypothesized that the intervention would deliver meaningful improvements in participants' outcomes.

Aim 3: SHOW data study. To determine the demographic, socioeconomic, screen-time, parental, and neighborhood correlates of accelerometer-measured physical activity and sedentary behavior of 6-17-year-old children and adolescents. It was hypothesized that meaningful associations between the potential correlates and the activity outcomes would be observed.

Chapter 2 - Aim 1: ACTIWEB-PA manuscript 1

Title: Intervention satisfaction and feasibility of the ACTIWEB-PA (Active Children Through In-home, Web-based Physical Activity) pilot randomized controlled trial in children.

Abstract

Introduction: Web-based movement integration programs are gaining popularity as a way to promote physical activity among children in a home setting. However, there is currently a lack of evidence regarding their acceptability and effectiveness. In the current study, we evaluated the intervention satisfaction and feasibility of Active Children through In-home Web-based Physical Activity (ACTIWEB-PA) trial, as part of which a movement integration intervention was delivered among children.

Methods: In the ACTIWEB-PA pilot randomized controlled trial, insufficiently active children aged 8-11 years (n = 82) were randomly assigned to an exercise intervention group (n = 41) or a wait-list control group (n = 41). The intervention group completed 20 minutes of moderate-to-vigorous intensity movement integration videos per day, 5 days per week, for a duration of 12 weeks using the UNICEF Kid Power website. The intervention was unsupervised, self-directed, and took place at participant homes. ActiGraph GT3X+ BT accelerometers were worn for 7 consecutive days at baseline and follow-up. All participants also completed surveys at baseline and at 12 weeks to assess intervention effects. Weekly exercise video completion logs were completed by parents in the intervention group. Feasibility outcomes were recruitment and retention rates with *a priori* targets of 50% and 80% respectively. Intervention adherence was measured as a percentage of participants completing ≥ 70% of the prescribed movement integration videos. Intervention satisfaction was assessed by surveys and end-of-study interviews with parent-child dyads in the intervention group.

Results: Of the 125 children who were screened and eligible, 92 consented/assented, yielding a recruitment rate of 73.6%. Randomized participants (n = 82) were 9.2±1.1 years old; 51% (n = 42) female, and 79.3% (n = 65) non-Hispanic white. Follow-up intervention

effectiveness surveys at 12-week were completed by 77 participants (retention rate-1: 93.9%) and valid follow-up accelerometer assessments were returned by 66 participants (retention rate-2: 80.5%). Sixty-nine percent (n = 25) participants in the intervention group had high adherence to the intervention as they completed at least 70% of the prescribed exercise videos. The exercise intervention was perceived as appropriate, pragmatic, and enjoyable based on results from qualitative analyses. Strategies used by families to increase adherence included integrating exercise videos into daily schedules and exercising together as a family. Suggestions were made to enhance video variety and novelty and to add a social/peer component. Despite declining adherence in warmer months due to competing outdoor activities, the intervention boosted higher overall spring activity levels.

Conclusion: The ACTIWEB-PA trial was found to be feasible, as recruitment and retention rates exceeded prespecified thresholds. Intervention adherence also surpassed comparable evidence. The exercise intervention was perceived as enjoyable, pragmatic, and acceptable. To sustain interest throughout the intervention, future trials should consider incorporating modifications to enhance novelty and variety. Additionally, future studies should capitalize on the benefits of peer participation and social environment for exercise adherence.

Introduction

Participation in regular physical activity confers health-enhancing benefits in children, including improved cardiorespiratory and muscular fitness, cardiometabolic health, weight status, bone health, cognition, as well as reduced risk of depression (60). Regular physical activity in youth can also prevent future development of cardiovascular disease, obesity, osteoporosis, cancers, and type-II diabetes (2). With an aim to reap these benefits, instructor facilitated school-based physical activity interventions have been traditionally offered to children and adolescents. These interventions are typically delivered as part of physical education, recess, after- and before-school programs, or during class itself (61). Despite the prominence of school-based physical activity programs for children, there has been a recent rise in the adoption of electronic health (eHealth) programs by families (62,63). eHealth programs are defined as "health services and information delivered or enhanced through the internet and related technologies" (16). These internet-based platforms have become increasingly popular, driven by children's growing familiarity with digital devices and the accelerated digitalization during the COVID-19 pandemic (64,65).

eHealth physical activity programs are likely to remain acceptable even as the pandemic has subsided, as children continue to gain access to and comfort with technology. As a result, these programs are expected to grow in popularity and may even coexist with in-person physical activity offerings (66,67). Therefore, it is important to evaluate the potential health impact of these web-delivered programs targeted towards youth that can be done from home. The investigation of these programs is an area that has received relatively limited research attention. However, a small-scale systematic review that included 10 web-based physical activity intervention studies demonstrated significant improvements in physical activity outcomes in youth (22). The intervention modalities in this review included informative articles and tutorials delivered via websites, mobile applications (apps), and emails (22). Another set of popular web-based physical activity interventions for youth include mobile apps for physical activity goal setting, monitoring, and positive reinforcement (23–25), mobile-based social-media apps for peer support (26,27), and digital console based exergames or active video games (28–30), Emerging evidence suggests that both mobile-based physical activity interventions and active video games may be promising strategies to promote physical activity among children (30,31).

In recent years, movement integration programs delivered through exercise videos have gained popularity as an eHealth approach to promote physical activity among children (32). These web-based programs consist of high-energy, exercise and dance videos performed by models, which children can follow along with using digital devices. These programs are commonly utilized in schools to provide movement breaks throughout the day (32,33). Furthermore, they have become increasingly popular for promoting physical activity at home (34). However, despite their widespread acceptance, there have been limited evaluations conducted on movement integration programs thus far (35). Among these evaluations, only one small non-randomized study with a sample size of 16 was conducted in a school setting (36), while the other two were informal, non-peer reviewed evaluations also conducted at schools (37,38). However, to the best of our knowledge, the feasibility and satisfaction with movement integration programs for children have not been rigorously studied in a home-based setting.

Thus, the primary aim of the Active Children through In-home Web-based Physical Activity (ACTIWEB-PA) study was to address this research gap by assessing the feasibility of study processes and examining satisfaction with a remotely delivered, youth-targeted, web-based movement integration intervention in a home setting. The movement integration program was delivered through the UNICEF Kid Power web platform, which offers freely accessible dance, sport, and fitness videos for children (68). We hypothesized that the study would be feasible to implement, and that the exercise intervention would be well-received by the participants.

Methods

Study Design

The ACTIWEB-PA study was a two-arm, parallel-group, pilot randomized controlled trial designed to assess the feasibility, satisfaction, and effectiveness of a youth targeted, 12-week movement integration intervention. The study protocol was registered in the ClinicalTrials.gov database (NCT05254483). All procedures were approved by the University of Wisconsin–Madison Education and Social/Behavioral Sciences Institutional Review Board. The checklist for reporting pilot trials by Consolidated Standards of Reporting Trials (CONSORT) was followed to prepare the manuscript for this study.

Participants

Participants were 82 children recruited from the greater Madison area and the nearby counties within Wisconsin. The inclusion criteria for the study were: (1) all children aged 8-11 years in a family (siblings eligible), (2) insufficient physical activity [not meeting the federal physical activity guideline of 60 min/day of moderate to vigorous physical activity (MVPA)] (60), (3) living with at least one parent in the same household, (4) availability of internet in the household, (5) availability of a smart-phone, computer, or an electronic tablet in the household, and (6) ability of the participant and at least one parent to communicate in English language. Exclusion criteria were (1) developmental, learning, and mental health disorders as diagnosed by a physician, (2) Parent reported disability/impairments that would interfere with the child's ability to safely perform the exercises in the videos. These included motor and sensory disabilities and impairment.

Procedures

Recruitment for the ACTIWEB-PA study began in January 2022, utilizing strategies such as the University of Wisconsin mailing service for staff and students, local community flyers, and social media advertisements in Wisconsin-based groups. Upon successful completion of the initial eligibility screener, oral assent from the child and informed consent from a parent were obtained through online video calls with families. Following the consent procedures, consented participants completed baseline assessments, which included parent-reported demographic surveys, child-reported PedsQL and Piers Harris surveys, and accelerometer-based data collection on 7 consecutive days (week 0). Using a randomization scheme in REDCap (69), participants with valid baseline data were assigned to either the exercise intervention group (EIG) or the wait-list control group (WCG) with equal probabilities. For feasibility reasons, randomization was performed at family level so that eligible siblings in a family would be assigned to the same treatment group. The randomization sequence was generated by L.C.B. and uploaded to REDCap project and data management software. Participants were enrolled by S.R.

Upon enrollment, the participant and a parent in the EIG were provided with detailed information regarding the exercise intervention. This included instructions on creating an account on the website, accessing the exercise videos, exercise video prescription, and tips to enhance adherence. These details were conveyed to the families through an online video call with the research team (week 0). Parents of the participants in EIG also completed weekly exercise video completion logs, mid-study surveys (week 6), and end-of-study intervention satisfaction interviews (week 12). Both treatment groups completed end-of-study assessments that included child-reported PedsQL and Piers Harris surveys and accelerometer-based data collection on 7 consecutive days (week 12)[1]. All surveys were completed online through REDCap software. Accelerometers, daily wear logs, and prepaid self-addressed mailers (to return the accelerometers back to research team) were mailed to participants' residential addresses at baseline and the 12-week follow-up. Data collection for the ACTIWEB-PA study took place between January and August 2022. All children who completed the follow-up assessments (accelerometry and surveys) were provided with a $100 incentive.

Intervention Description

Exercise Intervention Group (EIG)

The ACTIWEB-PA exercise intervention was developed in guidance with the *Supportive, Active, Autonomous, Fair, and Enjoyable* (SAAFE) framework for physical activity program delivery for children and adolescents developed by Lubans et al. in 2017 (70). The SAAFE framework has been informed by the self-determination theory (71). While the framework is primarily applicable to organized and supervised physical activity programs such as those conducted in schools or after-school programs, we drew upon those components of the framework that seemed relevant to our web-based, self-directed, and unsupervised program. In the following sections, we provide a detailed description of the movement integration intervention and how the SAAFE framework's principles were applied to it.

Participants in the EIG received a movement integration program through the freely accessible UNICEF Kid Power website (https://gokidpower.org/families-2/) for a duration of 12 weeks (68). The videos on the website were designed in a follow-after format, which promoted

[1] The results of the accelerometer, PedsQL, and Piers Harris outcomes are reported and discussed in a subsequent paper on intervention effectiveness. In this paper, we only utilize the metric for completion of follow-up assessments to compute the retention rate.

interaction and active viewing (Figure 1). At the beginning of the intervention period, the UNICEF Kid Power website featured approximately 50 movement integration/exercise videos, with 2-3 new videos being added sporadically every other week. The exercise videos on the website were classified into 3 categories, moderate energy dance, high energy dance, and sport, and fitness videos based on the level of energy expenditure. The sport and fitness videos aimed to elicit at least moderate energy expenditure and focused on teaching sport skills like basketball and martial arts, while also including strength-building exercises such as push-ups, squats, and jumps. Participants in the EIG were prescribed to select at least 5 exercise videos per day from over 50 options across these three categories *(Autonomy)*, on at least 5 days a week. On average, the videos on the website were approximately 4 minutes in duration. The prescribed physical activity dosage of nearly 20 minutes per day of MVPA was expected to supplement children's regular physical activity and assist them in achieving the federally recommended daily physical activity target of 60 minutes or more of MVPA per day *(Active)* (60). Participants were permitted to accumulate physical activity using the exercise videos in short bouts throughout the day and on any 5 days of the week *(Autonomy)*. Notably, the intervention was self-directed and unsupervised, allowing children to have control over the timing, location, and selection of exercises within the boundary of prescribed volume of exercise *(Autonomy, Enjoyable)*.

Families were encouraged to join the participating child in exercises to enhance intervention adherence and enjoyability *(Enjoyable, Supportive)*. The role of parents in facilitating the child's successful completion of the exercises was emphasized. Parents were responsible for ensuring that there was enough indoor or outdoor space available for the child to safely exercise in. Additionally, parents were expected to make the digital device available to the child during the exercise sessions and assist in troubleshooting technical challenges that might arise *(Supportive).* To promote intervention adherence and retention, parents received a weekly email reminder encouraging their child to complete the prescribed exercises *(Supportive).* The weekly email contained evidence-based articles on the importance of physical activity in children, as well as reminders to complete the weekly exercise video completion logs and surveys. A unique feature of the movement integration program was the website's built-in philanthropic incentive system. Participating children could earn virtual "coins" by completing the assigned videos, which could then be spent on local causes such as planting trees and delivering food to other families *(Enjoyable).* Although this was an optional component, it was hoped that the unique incentive system would promote adherence and engagement.

Waitlist control group (WCG)

During the 12-week treatment period, participants in the WCG continued to perform physical activity as usual. To maintain engagement with the trial, parents in the WCG received a weekly email newsletter on healthy dietary practices, which they were advised to share with their children. The newsletters did not address physical activity. At the end of the 12-week treatment period, the WCG was offered the exercise intervention via email or mail, based on participant preference. However, no data were collected on the outcomes.

Measures

Recruitment, Retention, and Intervention Adherence

Recruitment rate was calculated as the percentage of participants recruited into the study of those who met the eligibility criteria (72). Based on previous evidence, *a priori* target of 50% was specified for the recruitment rate (72). Retention rate was defined as the percentage of randomized participants completing the 12-week assessments (73). It was further broken down into the percentage of participants who completed the 12-week surveys on intervention effects (retention rate-1) and participants who completed the 12-week accelerometer assessment and provided valid wear-time data (retention rate-2). Valid accelerometer wear-time was defined as wear of at least 10 hours on 5 days (74). An *a priori* target of 80% was specified for each of the retention rates (73). Intervention adherence was classified into two; high and low. High adherence was defined as the percentage of participants performing at least 70% of the prescribed exercise videos during the 12-week intervention period. Conversely, low adherence was defined as the percentage of participants performing under 70% of the prescribed exercise videos (75). For adherence rate computation, the participants who dropped out (n = 3) and those who were lost to follow-up (n = 2) were excluded from the denominator. To collect information on adherence, parents of the participants in the EIG completed weekly exercise video completion logs during the 12-week intervention period.

Acceptability and Satisfaction

We determined intervention acceptability and satisfaction via a short parent-reported survey and end-of-study interviews with the parent-child dyads. The survey was completed at mid-study (6-week) and an end of study (12-week) by the parents of children in EIG. This brief survey was designed by the investigators and was guided by the aims of the study. Two questions in the survey assessed the parent's perception of their child's enjoyment of the exercise videos, four assessed barriers to participation in the exercises (i.e., time requirement, space requirement, technological challenges, and device availability). The responses were collected on a Likert scale ranging from 'all the time,' 'most of the time,' 'sometimes,' to 'never'. The last two questions assessed the parent's perceptions of changes in child's physical activity and energy levels. The responses ranged from 'yes, it has increased,' 'no, it has decreased,' to 'no change.'

Intervention acceptability and satisfaction were assessed through an online end-of-study semi-structured interview with both the participating child and a parent at week 12. In the interview, typically the parent was interviewed first, followed by the child. A schedule containing open-ended questions with prompts guided the interview process (see appendix). Parent-child dyads were asked about their perceptions of the exercise program, satisfaction with the program components, changes in physical activity over the intervention period, challenges faced, strategies for adherence, and suggestions to improve the intervention. A total of 29 interviews were conducted, involving 34 participants and 29 parents, with siblings being interviewed together. Interviews lasted approximately 30 minutes, were conducted online over a video call, audio-recorded, and transcribed.

Throughout the intervention period, safety while performing the exercises was monitored. Parents in the EIG were advised to report any adverse events resulting from the performance of the movement integration videos in the weekly reinforcement email.

Data Analyses

Descriptive statistics, including means and standard deviations (SDs), were used to summarize the baseline continuous variables such as sociodemographic, anthropometric, and parental factors. For categorical variables, absolute numbers and percentages were reported. Descriptive statistics were used to evaluate the feasibility and acceptability outcomes. All quantitative data analyses were performed on SAS 9.4 (SAS, Cary, NC).

To analyze the qualitative data, we used the step-wise thematic analysis framework (76). The audio-recordings of the interviews were first transcribed by three research team members and crosschecked for any transcription errors. The transcribed files were then uploaded in the Dedoose v9 software for analysis (77). Two researchers began the analysis by first familiarizing themselves with the transcribed data and developing initial codes. An integrative approach to code development was employed, wherein codes were based on both predetermined study outcomes (deductive approach) as well as novel codes that emerged from the data (inductive approach). The additional codes that emerged from data that were not prespecified were, ‘seasonal variation in uptake of the exercise intervention’ and ‘adding a peer/social component to the exercise intervention.’ Through an iterative process, both the researchers refined the codes by merging and removing redundant ones.

During the coding process, inter-rater reliability was assessed throughout, and discrepancies between researchers were discussed and resolved when Cohen's kappa was below 0.8. Once an agreement was reached, coding revisions were made to previously coded transcripts. We tested 10% of the excerpts for inter-rater reliability, at which point we achieved Cohen's kappa > 0.8. The coded excerpts were then compared and analyzed to determine relationships and create overarching themes and subthemes. The themes and subthemes were reviewed and refined by consolidating coherent patterns, discarding unnecessary ones, and reparenting. Following this iterative process, the themes were named. Please refer to Table 3 for a list of themes and subthemes obtained as a result of the thematic analysis.

Results

A total of 82 participants from the Midwestern United States were enrolled in the ACTIWEB-PA study. The CONSORT diagram in Figure 2 shows the flow of participants through the study. A total of 149 children were assessed for eligibility via an online screener survey, and 125 met the eligibility criteria. Of the eligible children, 73.6% (n = 92) completed the consent and assent procedures and were recruited in the study (recruitment rate) and 65.7% (n = 82) were randomized into the treatment groups after completing the trial run-in period; 41 in

EIG and WCG each (enrollment/randomization rate). Two participants in the EIG were lost to follow-up and 3 dropped out due to time constraints and lack of interest. There were no losses to follow-up in the WCG. Of the 82 enrolled participants, 93.9% (n = 77) completed the follow-up surveys at 12 weeks (retention rate-1), and 80.5% children (n = 66) returned valid accelerometer wear-time measurement at 12 weeks (retention rate-2).

Participant characteristics at baseline

The baseline participant characteristics for the sample and the treatment groups are summarized in Table 1. The mean age of the participants was 9.2±1.1 years. Fifty-one percent of the participants (n = 42) were female and 79.3% (n = 65) were non-Hispanic white. The majority of participants (57.3%) had an annual household income of more than or equal to $100,000. Approximately 40% of participants were overweight or obese. More than 90% of mothers and 80% of fathers had an undergraduate degree or higher. Nearly a quarter of parents (mother: 24.4%, father: 23.4%) achieved the recommended weekly MVPA ≥ 150 minutes.

Recruitment, Retention, and Intervention Adherence

In the ACTIWEB-PA study, 92 participants were recruited of the 125 eligible participants thus yielding a recruitment rate of 73.6%. Of the randomized participants, 93.9% completed the follow-up surveys (retention rate-1) and 80.5% returned valid follow-up accelerometer data at 12 weeks (retention rate-2). Both the study recruitment and retention rates surpassed the preset thresholds of 50% and 80% respectively (72,73). Participants in the EIG completed an average of 230±94 videos over the intervention period, accounting for 76.6% of the prescribed videos. Of the 36 participants who completed the exercise intervention, 11 (30.6%) had low adherence to the exercise intervention, meaning they completed < 70% (< 210 videos) of the exercise videos during the intervention period. The remaining 25 (69.4%)

participants in EIG had high adherence to the intervention as they completed ≥ 70% of the prescribed number of exercise videos. Among girls, 12 (66.7%) and among boys, 13 (76.5%) completed ≥ 70% of the videos. The overall intervention adherence was acceptable relative to previous evidence (78). However, there was a declining trend in weekly adherence to the intervention over time, as illustrated in Figure 3. The percentage of high adherers averaged 78.7% in the first 6 weeks but decreased to 64.8% in the last 6 weeks of the intervention.

Acceptability and Satisfaction

The acceptability of the intervention was assessed through a parent-reported survey at mid-study (6 weeks) and repeated at 12 weeks, as well as end-of-study interviews with parent-child dyads at 12 weeks.

Parent reported mid-study and 12-week survey

The completion rate for the mid-study survey was 85.4% (n = 35) and the 12-week survey was 80.5% (n = 33). According to the parent report, exercise videos held interest most or all the time for 69.7% (n = 23) children at 6 weeks and 48.5% (n = 16) at 12 weeks. Additionally, 39.4% (n = 13) children looked forward to exercising using the videos most or all the time at mid-study and 30.3% (n = 10) at 12 weeks. Sixty-seven percent of children at mid-study point and 57% at 12 weeks were able to find time to exercise using the videos most or all the time. Other than ‘time’ being a slight barrier, no other notable barriers to exercise participation were reported (barriers assessed: time requirement, space requirement, technological challenges, and device availability). According to parent reports, increases in children's energy and physical activity levels were higher at 12 weeks compared to the mid-study point. Additionally, there were no adverse events reported by parents as a result of their children exercising using exercise videos during the 12-week intervention period.

End-of-study interviews

A total of 29 interviews were conducted with EIG families at week-12, including 34 children and 29 parents. Among these interviews, 5 were conducted with families that had sibling participants. Interviewee details are shown in Table 2. Through the qualitative analysis, four main themes emerged. These themes are supported by subthemes (See Table 3).

Theme 1: Accessible, fun, rewarding, and more active opportunities

This theme pertains to the satisfaction expressed by both children and parents regarding the intervention, as well as the perceived value they derived from it. It covers the opinions regarding the practicality (i.e., age-appropriateness, time required, ease of accessibility, and technological demands), enjoyment (i.e., fun, interesting, engaging, variety, novelty, autonomy, learning, and educational value,), social justice aspects (i.e., rewarding and helping others, etc.), and the perceived impact of the exercise intervention on physical activity levels of children. This theme is supported by several subthemes: (a) Appropriate and pragmatic, (b) Enjoyable, (c) Social justice, and (d) Impact on physical activity levels.

Subtheme 1: Appropriate and pragmatic

In general, parents regarded the exercise program as ‘child appropriate’ and ‘easy to do,’ and ‘not too time consuming.’ For instance, parent-8 [P-8] reiterated the pragmatic nature of the program in the following statement,

> There was not anything that I found on there that I was offended by or did not like. [my child] liked everything, and I thought everything was appropriate. I liked the amount of time it took for [my child] to do it.

In addition to commenting on the appropriateness of the program, parents also shared the ease of accessibility of the program. For example, P-35 shared, “I liked that it was really easy for [my child] to do it on his own. After he logged on a few times, it was very seamless to log in. The process worked well.” Another parent, P-83 stated, “It was similar to those videos that she had used previously, so I liked that part and then the ease of going online and doing the program.” The movement integration intervention was thus deemed as pragmatic, easy to access, and appropriate.

Subtheme 2: Enjoyable

Children (n = 13) and parents (n = 10) shared that the exercise videos were enjoyable. In this context, "enjoyable" refers to the quality of the videos that made them fun and engaging. According to participant feedback, the videos that provided them with an opportunity to dance (children, n = 7) were more popular than those that taught sports skills (children, n = 3). Children also shared what they enjoyed the most about the exercise videos. For instance, child-126 [C-126] commented, “I liked…that they [models in the videos] told you what to do and did not just dance.” Another child, C-85, also shared comments on her enjoyment with the dance videos, “Some of the dance moves were really cool.” In addition to dance, the children appreciated the variety and the flexibility to choose between the video types. For example, C-69 commented, “My favorite part was learning new stuff, like different stretches” and C-103 added that their favorite part was the “The ability to choose between all of them.” Parents also commented on children’s enjoyment with the exercise videos and recalled these as ‘hilarious,’ ‘catchy,’ ‘entertaining,’ and ‘fun.’ For example, P-40 asserted, “We thought the videos were hilarious, so it made it a lot easier to, you know, be moving along with them because they were really entertaining and very catchy.” The parents also appreciated the children’s ability to choose from several videos, for example, P-143 shared, “There's good variety of videos and some he really seems to latch onto and do over and over again.”

Subtheme 3: Social justice

The philanthropic incentive system built into the UNICEF Kid Power website received positive feedback from both parents (n = 10) and children (n = 9). This system enabled children to exercise social justice by earning and donating digital coins to a helpful cause in their community after completing exercise videos. For instance, C-35 commented on his favorite part of the program. He articulated, “Where it had the coins, and you knew you were helping.” Thus C-35 appreciated that the intervention allowed him to help by donating the digital coins to those in need. Parents also commented that this social justice incentive motivated the children to engage in more exercises. P-17 shared in this regard, “The social justice or the philanthropy part of the website is really cool. I think that's an encouraging factor that [my child] really liked.” Similarly, P-151 noted, “She would get coins through the activities which was a really nice reward for her.” Thus, the testimonies revealed that the philanthropic incentive not only motivated the children to exercise but also empowered them to make a positive impact on their community.

Subtheme 4: More Active

To measure the satisfaction with the exercise intervention, parent-child dyads were also asked about the perceived impact of the exercise videos on participants’ overall physical activity levels. Most participants shared that the exercise videos contributed to enhancing their overall physical activity levels. For instance, C-83 commented in this regard, “I think I've definitely become more active. Especially since I don't get out much… I normally just sit around at school; you sit at a desk. I definitely think that this is making me more energetic than usual.” According to the parental feedback, the videos motivated the children to be active and allowed them to get out of their normal routines. P-69 described the changes in her child's activity levels in the following excerpt,

> On his days off, he normally would just sit down and watch TV after he's done with his day but because he had to watch the videos, he was active towards the end of the day. You know on those days, it increased it for sure.

Child participants also shared that the videos made them feel more energetic. For instance, C-35 expressed, "I might have been more active because I want to run around after the exercises, because I'm a bit more hyped up." Overall, parents and child participants conveyed high levels of satisfaction with the exercise video program's various components. They deemed it appropriate, pragmatic, accessible, fun, and engaging. Additionally, the program's flexibility, which provided participants with a range of videos to choose from, as well as its social justice aspects, were received positively by both parents and children. Furthermore, children benefitted from the exercise program, becoming more physically active than usual.

Theme 2: Decline in interest

This theme highlights the perceived barriers for engagement with the intervention over time. Despite parents and children having an overall positive view of the exercise program, some parents (n = 8) noted a decline in their children's interest in the intervention over time. Two reasons were reported for this decline in the latter part of the treatment period. Firstly, an increase in monotony and boredom over time due to a decline in novelty and variety of videos available and the repetitive nature of the intervention over the 12 weeks. Secondly, changes in exercise video adherence due to seasonal changes, such as reduced participation in the program during the warmer months and competing demands from outdoor activities. This theme is supported by two subthemes, (a) Monotony and (b) Seasonal variations in exercising.

Subtheme 1: Monotony

Parents (n = 2) and children (n = 2) reported that the exercise intervention became monotonous and dull over time due to a decline in the novelty. In this context, "novelty" refers to the quality of the exercise intervention that keeps it engaging and enjoyable by providing new experiences and varied content. P-35 shared her insights about this, “In the beginning there were new videos, and he had not seen them before…and overtime the novelty of it wore off.” Sibling participants, C-57 and C-58 suggested adding novel videos to keep the exercises interesting. In this regard, participant C-57 shared, “Doing the same videos over and over again was dull.” C-58 expanded, “I agree with him. I wish every so often they added new videos.” Another participant, C-121, also expressed how the repetitive nature of the intervention made it seem ‘boring’, “It wasn’t my favorite. Because you have to do it five times every week. It kinda gets boring you know.” Interview feedback thus highlighted that incorporating novel videos periodically may enhance engagement and prevent monotony in the intervention over time.

Subtheme 2: Seasonal variations

The second reason for a decline in children's participation in exercise videos over time, as reported by parents, was due to an increase in demands on the children's time during spring and summer related activities. For instance, parents mentioned that when the intervention began in January/February 2022, children were more likely to be at home in the evenings due to the cold weather. As a result, they had more time and interest in the movement integration program. As the program progressed into the warmer months of April/May 2022, children became more interested in outdoor free play and other organized sports, resulting in reduced interest and time for indoor exercises (Parents, n = 6). For example, P-149 stated, “I think when it was not as nice outside…this [exercise videos] added a lot more physical activity. When it is nice outside, we like to do more stuff like hiking.” P-130/133 also shared similar sentiments, stating that “We had some difficulties when the weather got warmer and towards the end of the school year when they had more activities going on with school.”

Moreover, parents faced the challenge of justifying the usefulness of the intervention to their children during the warmer spring months, when outdoor activities were already abundant. P-115 expressed, “When soccer started, that's when it got hard because [my child] was like, ‘but I already exercised today’.” Parents also noted the winter weather utility of the exercise program, with P-57/58 stating, "I think the study was a nice jump start. Since it started in the colder part of the year, and you get a little sedentary.” The exercise intervention was thus deemed helpful in addressing lower physical activity levels that are typical of children during winter weather.

In brief, participants reported a decline in interest and adherence to the intervention over time, which was attributed to two reasons. Firstly, an increase in monotony due to the limited novelty of the exercise videos and the repetitive nature of the program. Secondly, seasonal variations in exercise uptake were noted, with children having competing demands on their time due to spring activities. These findings underscore the importance of designing exercise interventions that can maintain children's interest and engagement over time, particularly during seasonal transitions.

Theme 3: Role of routines and family

This theme unpacked the strategies employed by families to increase adherence and compliance to the exercise intervention. The first strategy shared by parents was to incorporate the exercises into the child's daily schedule (e.g., making it a routine, having checklists). Another effective strategy was to exercise together as a family. Thus this theme is supported by two subthemes, (a) Incorporating exercises in daily schedule and (b) Exercising as family.

Subtheme 1: Incorporating exercises in daily schedule

While we were unable to obtain children's voices on this subtheme, according to most parents (n = 15), incorporating the movement integration exercises into their children's daily routine greatly improved intervention adherence. Most children performed the exercises on weekdays, typically after school. For example, P-83 mentioned, "you come home you get like a certain amount of downtime and then go ahead and knock out your videos for the day, so [my child] had that routine with it." P-69 also shared the value of having a daily routine, "We tried to do it at the same time every day, like 'do it before you go to sleep'. Usually, it was in the afternoon or evening...that helped." Even children who were homeschooled included the exercises in their daily schedules. For example, P-8 stated,

> Having a routine of when we did it tended to work really well. Tuesday and Thursdays [my child] is homeschooled, so it was included in her activities for the day. We liked to incorporate it in the middle of schoolwork. And on other days, she tended to do it right after dinner. That became a routine and then it always happened.

Parents also reported that using checklists or a daily 'to-do' list proved effective in making intervention a habitual part of their child's routine. P-8 shared that, "I do have a checklist for [my child] and it [videos] was just on her list. Then it was part of her day."

Subtheme 2: Exercising as family

Another strategy employed by families to increase exercise compliance was to do the exercises together as a family. This was frequently cited as a key component that enhanced the children's enjoyment and motivation (Parents, n = 16, Children, n = 3). For example, C-17 stated, "It was fun because I bonded with my mom because we did together" while C-83 mentioned, "I kind of know that my mom and my dad and my sister would do it with me. That I'm not the only one that's doing exercises alone. I like that, so that motivated me to do it." Parents also noted that performing the exercises together as a family was a great motivator for their children. For instance, P-149 shared, "If [my child] was not motivated, I would say let's do it and she would be into it more, since I was there." Another parent [P-110] shared that doing the exercises together as a family enhanced the enjoyment, "The part I liked most was that it gave us an opportunity to do it together and she preferred it, so when we could do it together it was fun."

The findings under this theme suggest that incorporating exercises into daily routines and exercising together as a family were effective strategies to enhance adherence and compliance to the exercise intervention in our study.

Theme 4: How to make it appealing?

This theme delves into the suggestions made by the participating families to increase the attractiveness of the exercise intervention for children. Two recommendations were put forward and these are represented in the following two subthemes: (a) Variety is needed and (b) Addition of a peer/social component.

Subtheme 1: Variety is Needed

Under this subtheme, participants' and parents' views on enhancing the variety and novelty in the exercise program are described. Novelty has been defined in the preceding section. "Variety," in this context, refers to the inclusion of a sufficient number of diverse exercise videos, offering different movements, themes, or styles, to prevent monotony and maintain engagement throughout the intervention period. Increasing the variety and novelty in the exercise program was the most often cited suggestion for enhancing the acceptability of the intervention. Several child interviewees expressed that their interest decreased through the intervention period and recommended that new videos should be added to the website weekly to maintain interest. C-144 shared his perspective as follows:

> What I would have liked is if new videos were released every week. So maybe you only have a choice of 10 videos and then next week they'll be a different 10, or even a specific five each day, to change up a little bit so it's like "What am I gonna get today."

Some child participants had tried all the videos available and felt that there were not enough videos to choose from in the latter weeks. For example, C-83 shared, "I've done a lot of them and …. I don't want to do the same videos. I want to get something new and do different things."

In addition to increasing the novelty and variety of exercise videos, it was also suggested to diversify the videos beyond dance. Some parents stated that their children desired to see more videos focused on sports skills and fitness. For instance, P-121 shared, "At first, [my child] did not want to choose dance, so maybe if there are more choices…but he liked sports skills videos. Maybe more variety of those." P-83 expressed a similar sentiment, emphasizing the types of exercise videos that may be more suitable for children who do not enjoy dancing, "I think having some other ones that weren't dancing along to music would be really good too, like some you know little interval workouts or something that are kid friendly." Thus, enhancing the novelty of the exercise intervention and diversifying the types of videos were the key suggestions made by participating families.

Subtheme 2: Addition of a peer/social component

Another suggestion from parents was to incorporate a social component into the intervention, enabling children to exercise online with other participants or interact with them in some manner. Parents noted that this would motivate children to adhere more to the exercises. P-

113 shared, “If there would be a way to maybe do online meetup where the kids participating could encourage each other or share how they’re using their points. I think that would be a really motivating factor.” P-121 also suggested, “If [my child] knew other friends in study, they could zoom together and do it together.”

While we were unable to obtain direct feedback from participating children regarding this theme, several parents (P-40, P-60, P-115) reported that their children enjoyed exercising more when they had friends over to exercise with them. For instance, P-40 shared, “There are days when if she has friends over or her cousins over, she's done more of them because I think she's actually had a sense of pride with it.” This further corroborated the perceived value of peer participation on exercise enjoyment and adherence. Overall, the suggestions made by the participating families highlight the importance of variety and social interaction in enhancing the acceptability and adherence of the intervention for children.

Discussion

The aim of the ACTIWEB-PA pilot trial was to examine the feasibility of study processes and assess the acceptability and satisfaction of a remotely delivered, youth-targeted, web-based movement integration intervention in a home setting. The results demonstrated that the study achieved recruitment, retention, and overall intervention adherence rates that exceeded the predetermined thresholds. This indicates the feasibility of conducting future definitive trials with remotely delivered movement integration interventions for children. Generally, parents and children reported high satisfaction with the intervention, considering it appropriate, pragmatic, useful, and enjoyable. However, there were differences in engagement with the intervention, particularly in the later part of the intervention period. In the following sections, we summarize the key findings of the study and provide recommendations for developing and implementing future trials.

Self-directed, remotely delivered eHealth interventions often face challenges related to study retention and adherence, as documented in previous research (79,80). Unlike in-person interventions that provide supervision and assistance, remotely delivered eHealth interventions heavily rely on participant discretion, increasing the likelihood of discontinuation (80). However, our study exhibited high retention rates, with approximately 94% completion rate for 12-week surveys and 81% for valid accelerometer data, which is promising. These positive outcomes can be attributed to the convenience offered by online surveys and remote physical activity measurements. Moreover, our study demonstrated a low attrition rate (EIG = 12%, WCG = null) and showcased higher intervention adherence compared to a similar remotely delivered, web-based exercise intervention for youth offered as part of the AIMFIT trial (ACTIWEB-PA trial: high adherence = 69.4%, AIMFIT trial: high adherence = 31.3%) (75). In our trial, proactive measures were taken to enhance engagement, such as weekly reminder emails to parents, and provision of clear prescription of exercise volume and frequency. In contrast, the AIMFIT trial employed an *ad libitum* intervention approach, which may have contributed to lower adherence. Furthermore, the flexibility offered by our intervention, enabling participants to exercise at their convenience from the comfort of homes, and eliminating the need for travel, likely contributed to high participant adherence and low attrition rates despite the lengthy duration of our intervention.

Our exercise intervention was well received by participants with families expressing high satisfaction with the program. Importantly, the majority of participants found the exercise videos included in the intervention to be enjoyable. As our intervention was based on SAAFE principles rooted in self-determination theory, which emphasizes intrinsic motivation and enjoyment in promoting physical activity engagement, these findings were anticipated (70,81). Our findings align with previous research that has highlighted the significant role of enjoyability in shaping children's physical activity behavior. Studies have consistently demonstrated that when children find physical activities enjoyable, they are more likely to participate in them regularly (82,83). Therefore, our findings emphasize the importance of developing future exercise programs that prioritize enjoyability as a central theme, making them engaging, age-appropriate, novel, and varied to promote sustained participation and adherence.

Family participation emerged as another significant contributing factor to increased satisfaction and adherence in our exercise program. Although not an intervention stipulation, several families voluntarily chose to exercise together, reporting higher levels of enjoyment and adherence compared to children exercising alone. These findings are consistent with prior research on family-based physical activity interventions for children, which have shown higher program satisfaction (84,85). It is important to note however, that family-based interventions often encounter challenges related to scheduling and motivation. However, studies implementing goal setting and reinforcement intervention strategies have demonstrated increased family engagement, leading to improved physical activity outcomes (86,87). In our study, the value of family participation was explicitly expressed, highlighting the importance of creating a supportive social environment for children’s enhanced adherence to physical activity programs.

Further underscoring the importance of a social context, participants in our study expressed a preference for exercising in a group setting with peers. While in-person physical activity programs have established the positive influence of peers on children's physical activity levels (88,89), web-based remote intervention studies have yet to explore this hypothesis. To bridge this research gap, it is essential to investigate innovative approaches that facilitate online connections and enable children to exercise together virtually. By providing opportunities for virtual group exercise sessions or incorporating interactive features that promote peer interaction during exercise, web-based interventions can tap into the motivational power of the social environment. This approach has the potential to enhance engagement, enjoyment, and adherence among youth participants, ultimately leading to positive physical activity outcomes.

While overall, the exercise videos were enjoyable, weekly adherence rates and participant reports indicated a gradual decline in adherence over time. This finding is consistent with another study that evaluated a mobile physical activity intervention in adolescents, where lower adherence was observed during the latter half of a 12-week treatment period (90). While the reasons for non-sustained adherence were not reported in that study, our results indicated that the waning interest stemmed from the diminishing novelty of the videos with time. The significance of novelty in exercise adherence has been highlighted in studies examining predictors of adherence in both youth and adults (91,92). In these studies, it is recognized that in addition to providing variety, incorporating novelty into exercise programs is a key factor in promoting exercise uptake, particularly in the long term. Theoretical research also suggests that novelty-variety serves as a distinct psychological need, separate from the three basic psychological needs of autonomy, competence, and relatedness (93). Thus, based on our results, the inclusion of novelty as a fundamental aspect of program design has the potential to optimize adherence and facilitate long-term engagement with web-based exercise interventions for youth.

The change of season from winter to spring during the treatment period served as another reason for declining interest and engagement in the latter part of the intervention. Spring, with increased daylight and improved weather, promotes higher outdoor activity (94–97). Consistent with results from other studies, participants in our study preferred outdoor activities like hiking, cycling, and organized sports as spring arrived (98,99). Despite the decline in intervention participation, overall engagement in outdoor physical activity increased during spring. This finding is particularly encouraging as it indicates a rise in overall physical activity among initially insufficiently active participants in our study. Families reported that the intervention's role in initiating physical activity dialogue and engagement within families was the reason for its effectiveness in acting as a "jump-start" to greater levels of physical activity.

In addition to serving as a catalyst for higher physical activity achievement in spring, ACTIWEB-PA exercise intervention also impacted the lower physical activity levels typically observed during winter (94–97). Families in our study reported that the exercise videos provided valuable opportunities for physical activity during the colder months when staying active was more challenging. Given these findings, it is important for researchers to consider the distinct opportunities and challenges related to different seasons when designing future home-delivered, web-based physical activity interventions for children. Additionally, to better understand the effects of seasonal transitions on program uptake, interventions should span across all seasons. This approach will provide insights into how seasonality impacts participant engagement and adherence, enabling the development of interventions that address these variations throughout the year.

Strengths and Limitations

This study explored the feasibility of a novel home delivered, web-based physical activity intervention among physically inactive children. Its primary strengths included advancing the knowledge on remote assessments and intervention delivery for children and being the first formal evaluation of a remotely delivered movement integration program for children in a home setting. Consequently, the ACTIWEB-PA study serves as an important foundation for future research utilizing remotely delivered methods and web-based physical activity interventions, especially considering the increasing importance of technology in children's lives. The study also collected qualitative data that provided rich insights into participant perspectives on the intervention. However, it is important to acknowledge certain limitations that should be considered when designing future large-scale trials. The study population was relatively homogenous; white, affluent, and educated, predominantly recruited through the University of Wisconsin's mailing system, thus affecting the generalizability of our results. In addition, participants were recruited over a brief period ranging from January to March 2022. As a result, seasonality may have affected the findings, as there was a difference in uptake of the intervention during winter and spring months. Consequently, the results may not generalize to southern states such as Florida, Arizona, and Texas, where it is warm year-round.

Conclusion

In conclusion, the results of the ACTIWEB-PA study contribute to the limited evidence on the feasibility of remotely delivered web-based exercise programs for children. The pilot trial was feasible, and the movement integration intervention was deemed enjoyable, practical, and acceptable. Moreover, the intervention facilitated discussion about physical activity in households and acted as a catalyst for increased activity levels in children. However, future trials should include modifications to enhance the novelty and variety of the exercise program and account for variations in exercise uptake due to seasonality by extending the intervention duration. In addition, given the observed high adherence resulting from family participation and the expressed desire for peer involvement, we strongly recommend leveraging the social environment and connectedness in future web-based physical activity interventions aimed at youth. By incorporating these recommendations, future trials can potentially increase their effectiveness in promoting physical activity among children.

Figure 1: A screenshot of the UNICEF Kid Power website.

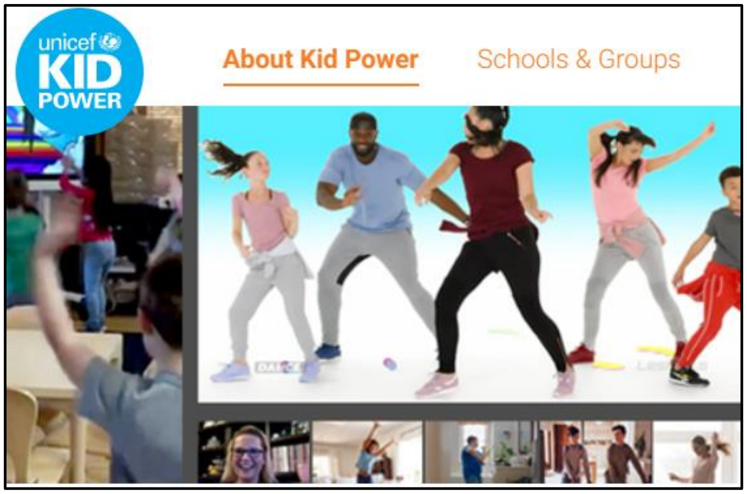

Figure 2: CONSORT Diagram

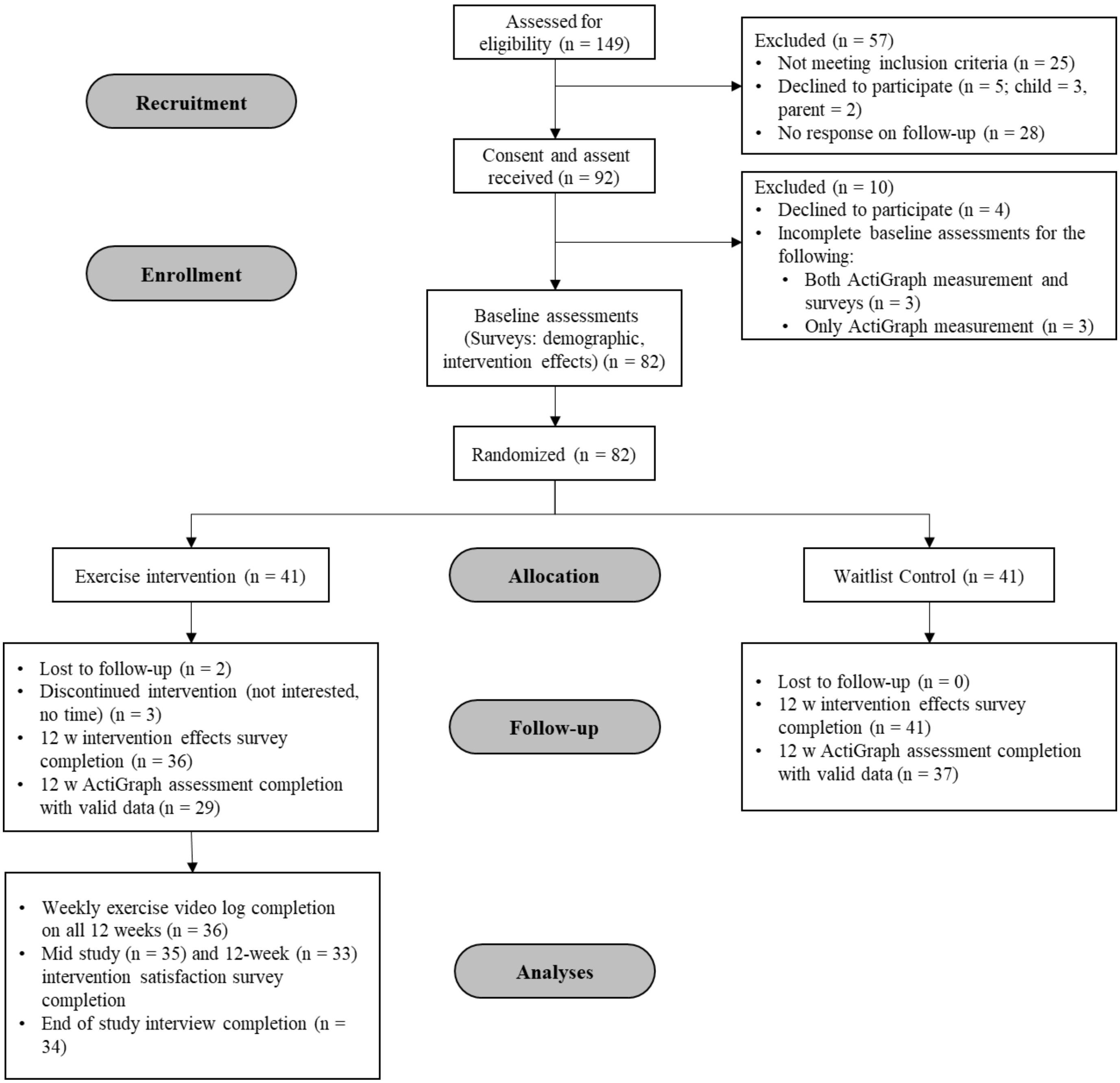

Figure 3: Trends in weekly adherence

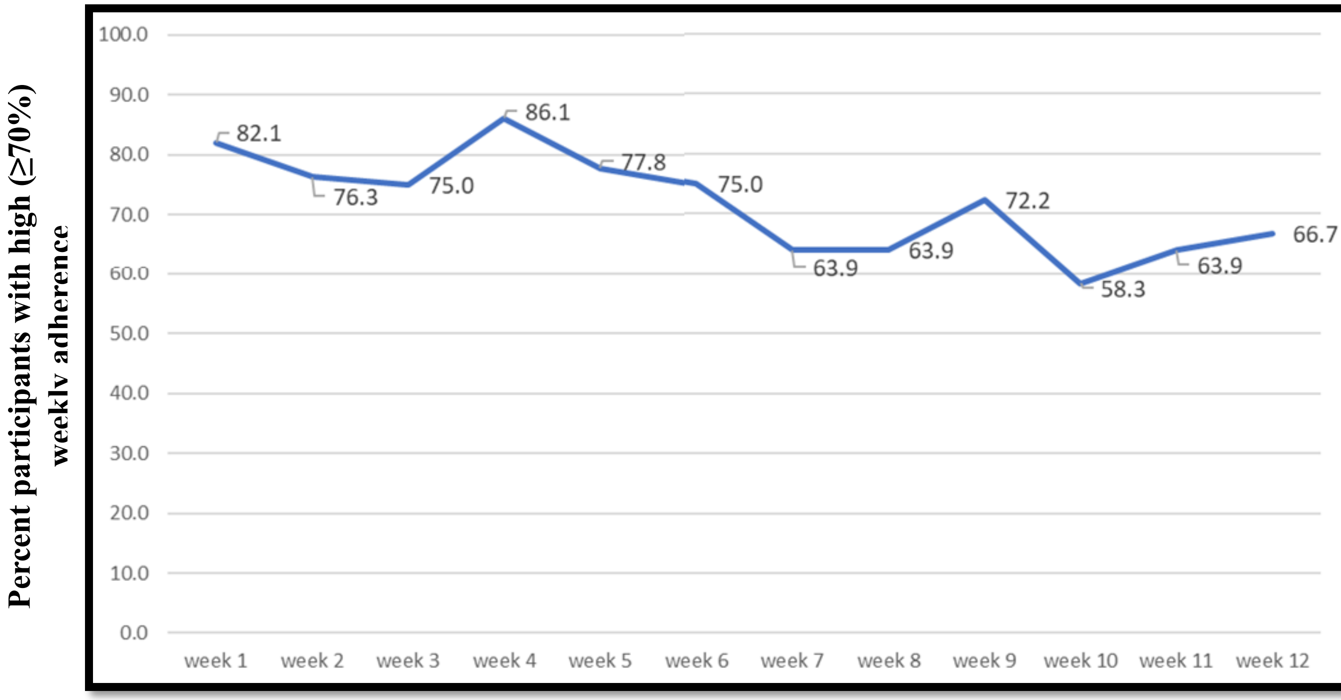

Table 1: **Baseline characteristics of participants**

	Total	**Exercise Intervention**	**Wait-list control**
	Mean (SD) or N (%)	Mean (SD) or N (%)	Mean (SD) or N (%)
N	82	41	41
Sociodemographic characteristics			
Age	9.2 (1.1)	9.4 (1.0)	9.1 (1.2)
Gender			
Male	39 (47.6%)	20 (48.8%)	19 (46.3%)
Female	42 (51.2%)	20 (48.8%)	22 (53.7%)
Other	1 (1.2%)	1 (2.4%)	-
Race			
White	63 (76.8%)	33 (80.5%)	30 (73.2%)
Black	6 (7.3%)	4 (9.8%)	2 (4.9%)
Asian	10 (12.2%)	4 (9.8%)	6 (14.6%)
Others	3 (3.7%)	-	3 (7.3%)
Ethnicity			
Hispanic or Latino	9 (11%)	3 (7.3%)	6 (14.6%)
Not Hispanic or Latino	72 (87.8%)	38 (92.7%)	34 (82.9%)
Prefer not to answer	1 (1.2%)	-	1 (2.4%)
Annual Household Income			
<$100,000	26 (31.7%)	13 (31.7%)	13 (31.7%)
$100,000-199,999	35 (42.7%)	17 (41.5%)	18 (43.9%)
≥$200,000	12 (14.6%)	6 (14.6%)	6 (14.6%)
Prefer not to answer	9 (11%)	5 (12.2%)	4 (9.8%)
Anthropometric characteristics			
BMI			
Healthy weight	47 (57.3%)	22 (53.7%)	25 (61.0%)
Underweight	3 (3.6%)	1 (2.4%)	2 (4.9%)
Overweight	14 (17.1%)	6 (14.6%)	8 (19.5%)
Obese	18 (22%)	12 (29.2%)	6 (14.6%)
Parental characteristics			
Mother's highest education			
High School	4 (4.9%)	2 (4.9%)	2 (4.9%)
Undergraduate	44 (53.7%)	21 (51.2%)	23 (56.1%)
Graduate	34 (41.5%)	18 (43.9%)	16 (39.0%)
Father's highest education			
High School	11 (14.3%)	8 (21.1%)	3 (7.7%)
Undergraduate	34 (44.2%)	20 (52.6%)	14 (35.9%)
Graduate	32 (41.6%)	10 (26.3%)	22 (56.4%)
Mother's self-reported weekly MVPA (minutes)			
>60	32 (39%)	15 (36.6%)	17 (41.5%)
60-89	15 (18.3%)	9 (22.0%)	6 (14.6%)
90-149	15 (18.3%)	4 (9.8%)	11 (26.8%)
≥150	20 (24.4%)	13 (31.7%)	7 (17.1%)
Father's self-reported weekly MVPA (minutes)			
>60	25 (32.5%)	10 (26.3%)	15 (38.5%)

60-89	21 (27.3%)	10 (26.3%)	11 (28.2%)
90-149	13 (16.9%)	7 (18.4%)	6 (15.4%)
≥150	18 (23.4%)	11 (29.0%)	7 (18.0%)

Note: BMI has been age and sex standardized based on CDC guidelines. The cut-offs are based on CDC growth charts (<5 kg/m^2: underweight, ≥5 kg/m^2 and <85 kg/m^2: healthy weight, ≥85 kg/m^2 and <95 kg/m^2: overweight, ≥95 kg/m^2: obese).

Table 2: Details of the interviewed participants

Participant ID	Age in years	Gender	Mother/Father
8	9	Female	Mother
17	11	Female	Mother
28	11	Male	Father
35	9	Male	Mother
36	9	Male	Father
40	10	Female	Mother
57*	11	Male	Mother
58*	9	Female	
60	9	Male	Mother
65*	10	Male	Mother
66*	8	Female	
69	10	Male	Mother
72	8	Female	Father
82	10	Female	Mother
83	8	Female	Mother
85	10	Female	Mother
100	9	Male	Mother
102	11	Male	Mother
103	9	Others	Mother
110	8	Female	Mother
113	10	Male	Mother
115	9	Female	Mother
121	10	Male	Mother
126	9	Female	Father

Participant ID	Age in years	Gender	Mother/Father
130*	10	Female	Mother
133*	10	Female	
138*	8	Male	Mother
139*	10	Male	
143	10	Male	Mother
144	9	Male	Mother
149	8	Female	Mother
151	8	Female	Father
153*	10	Female	Mother
154*	8	Female	

* Participants in the merged rows are siblings interviewed together

Table 3: Themes and subthemes used in the qualitative analysis.

Themes	Subthemes
Accessible, fun, rewarding, and more active opportunities.	Appropriateness, pragmatic
	Enjoyable
	Social Justice
	Impact on physical activity levels
Decline in interest	Seasonal variations
	Monotony
Role of routines and family	Incorporating exercises in daily schedule
	Exercising as family
How to make it appealing?	Variety is needed
	Addition of a peer/social component

Chapter 3 - Aim 2: ACTIWEB-PA manuscript 2

Title: Effects of a 12-week, remotely delivered, web-based exercise intervention on children's physical activity and psychosocial health: Results from the ACTIWEB-PA pilot RCT.

Abstract

Introduction: Regular physical activity is beneficial for children's wellbeing and psychosocial health. However, there is limited evidence on the effects of remotely delivered, electronic health (eHealth) physical activity programs for children. The Active Children through In-home Web-based Physical Activity (ACTIWEB-PA) pilot randomized controlled trial aimed to evaluate the effects of a 12-week, remotely delivered web-based movement integration program on accelerometer-measured physical activity outcomes, as well as self-reported health-related quality of life (HRQoL) and Self-Concept.

Methods: Insufficiently active children aged 8-11 years (n = 82) were randomly assigned to an exercise intervention group (n = 41) or a wait-list control group (n = 41). The intervention group participants were prescribed 20 minutes of moderate-to-vigorous intensity movement integration videos per day, 5 days per week, for a duration of 12 weeks using the UNICEF Kid Power website. The exercise sessions were self-directed, unsupervised, and took place at participant homes. Physical activity was assessed at baseline and at 12 weeks using hip worn ActiGraph GT3X+ BT accelerometers, while self-reported HRQoL and Self-Concept were assessed at both time points using the PedsQL and Piers Harris scales, respectively. Data were analyzed using mixed models.

Results: The mean age of participants was 9.2±1.1 years and 51.2% were female. Adjusting for baseline imbalances in outcome variables, there were no significant intervention effects on the primary outcomes, including minutes/day of total physical activity (β = -0.9, 95% CI: -31.4, 29.6, $p = 0.95$), sedentary time (β = -5.8, 95% CI: -39.7, 28.0, $p = 0.7$), light physical activity (β = 5.4, 95% CI: -21.6, 32.4, $p = 0.7$), moderate to vigorous physical activity (β = -8.5, 95% CI: -18.7, 1.7, $p = 0.1$), and steps/day (β = -78, 95% CI: -1138, 981, $p = 0.88$). Among the secondary outcomes, only behavioral adjustment sub-scale of the Piers Harris Self-Concept scale saw significant positive improvements (β = 3.3, 95% CI = 0.3, 6.2, $p = 0.03$). Our results were indicative of a gender-based variation in physical activity outcomes.

Conclusion: The remotely delivered web-based movement integration intervention in the ACTIWEB-PA pilot study did not deliver significant improvements in the primary or secondary outcomes of children in the study. Nevertheless, given the increasing interest in and utilization of remotely delivered eHealth interventions to promote physical activity among children, this study offers valuable insights for optimizing future trials in this field.

Introduction

Participation in regular physical activity in children is important as it confers numerous health benefits including improved cardiorespiratory health, bone health, and cognition (1,3). Emerging evidence also suggests that physical activity improves psychosocial well-being in children (6,11,100). However, more research is needed in this area, particularly since poor psychosocial health among children and adolescents is increasing in the US (101). Despite the recognized importance of regular physical activity, only 26% of 6–11-year-old meet the federal physical activity recommendations. This percentage drops even further to 15% in adolescence (7). Evidence indicates that self-esteem tends to decline during adolescence (102), which increases the risk of depression in late adolescence and early adulthood (103). Given the combined decline in physical activity levels and changes in self-esteem during childhood to adolescence, childhood becomes a critical "window of opportunity" for behavior change. Scalable, equitable, and accessible physical activity interventions are thus necessary to jump-start higher activity levels and promote long-term psychosocial health.

While physical activity programs in schools and before/after school settings are common among children (12–14,104,105), there is growing interest in electronic health (eHealth) physical activity programs that can be accessed from home (15). As access to the internet and digital devices continues to expand (20,21), these programs may promote health equity by providing additional physical activity options to children who may not have access to parks, sport clubs, and afterschool programs, are homeschooled, or live in areas where safety concerns limit outdoor play (17). Despite the growing popularity of eHealth physical activity programs for children that can be done from home, there is limited evidence on their effects on physical activity and psychosocial health. In a recent systematic review that examined the effects of eHealth exercise interventions on children's physical activity outcomes between 2015-2020, 8 randomized controlled trials (RCTs) were included, with only 3 of them being delivered at home (35). These RCTs investigated the effects on physical activity levels and potential mediators of behavior change, such as self-efficacy, enjoyability, and attitudes. However, none of the studies assessed the effects on psychosocial health outcomes, including health-related quality of life (HRQoL), self-esteem, positive affect, anxiety, and physical self-perceptions etc. (35).

To address this research gap, through the Active Children through In-home Web-based Physical Activity (ACTIWEB-PA) study, we implemented and evaluated a remotely delivered exercise program for children accessed via UNICEF Kid Power website (68). The UNICEF Kid Power website hosts a variety of exercise videos, which are part of a broader category of eHealth exercise programs for children known as movement integration programs (32)[2]. These programs feature dance, yoga, sport, and fitness videos in a follow-along format and can be accessed using any digital device connected to internet, such as a smart-phone, digital tablet, computer, or a TV. These have been widely used in schools to provide children with movement breaks and active indoor recess (32,38). In recent years, these programs have also been increasingly used by families to provide children with active breaks at home (66). To the best of our knowledge, movement integration programs for children have never been tested for their effectiveness at a home-based setting (35). Previously, a single evaluation of movement integration program has been performed at a school-based setting (36). However, this study was limited by its small

[2] Movement integration programs are sometimes classified under exergames/active video games because of similarities in types of physical activities, e.g., dance (36). However, movement integration programs differ from exergames on a couple accounts. First, exergames are primarily interactive video games such as Pokémon Go, Zombies, Run! etc. which require a gaming console such as a Wii U Sports or a Xbox One Kinect, and second the target population is typically adolescents, teenagers, and adults. In contrast, movement integration programs are targeted at children and are more accessible as they can be accessed using any digital device connected to the internet.

sample size of only 16 participants, a non-randomized intervention design, and the measurement of physical activity being limited to school hours. As such, transfer effects to children's overall physical activity could not be measured.

Therefore, using an RCT design, we aimed to overcome the shortfalls of the previous research and to build new evidence by empirically evaluating the effects of a remotely delivered, web-based, movement integration intervention on children's accelerometer measured physical activity outcomes. We also aimed to investigate the effects of the intervention on secondary outcomes of HRQoL and Self-Concept. It was hypothesized that the intervention would deliver meaningful improvements in participants' outcomes.

Methods

The design and methods of the ACTIWEB-PA study have been previously reported in detail (106). The study used a parallel group, randomized design with a waitlisted control arm. The primary results of the study, the feasibility outcomes have been previously reported (106). This paper reports the primary and secondary intervention effects of the ACTIWEB-PA trial that used a novel, youth targeted, web-based movement integration intervention. All procedures were approved by the University of Wisconsin–Madison Education and Social/Behavioral Sciences Institutional Review Board. Oral assents from participants and informed consents from parents were obtained before being randomized into the treatment groups.

Participants

Children were eligible for ACTIWEB-PA if they were: (a) between 8-11 years old, (b) insufficiently active based on 2018 physical activity guidelines (60), (c) fluent in English (both child and a parent/guardian in the same household), and (d) had access to a screened digital device with internet to access the intervention. Exclusion criteria were developmental (e.g., autism), learning (e.g., dyslexia) and mental health disorders (e.g., ADHD, oppositional defiant disorder, depression, anxiety, and other mental health disorders) as diagnosed by a physician. In addition, children whose parents reported disability or impairments that would interfere with their ability to safely perform the exercises were also ineligible. These included motor and sensory disabilities and impairment. Participants could be siblings of and/or living in the same household as other participants, as long as each child met the eligibility criteria.

Recruitment, randomization, and data collection

The ACTIWEB-PA study completed recruitment of eligible participants between January and March 2022. Local recruitment strategies such as University of Wisconsin mailing service, community flyers, and social media advertisements in local (Wisconsin) groups were used. After completion of the eligibility screener and consent procedures, participants were asked to complete the baseline procedures via REDCap. These included the child's background characteristics (parent reported), HRQoL (child reported), and Self-Concept (child reported) (week 0). Participants also received an ActiGraph GT3X+ BT accelerometer (ActiGraph, Pensacola, FL) along with a daily wear log. Physical activity assessment was conducted by having the participating child wear the accelerometer on the right hip for 7 consecutive days (week 0). Once the wear period was completed, participants mailed back the accelerometer and the completed log to the research team. Data were downloaded and screened for completeness and irregularities. Participants were asked to re-wear the accelerometer if they did not wear it for at least 10 hours per day on at least 5 days. Upon completion of the baseline surveys and receipt of valid accelerometer data, 82 participants were then randomized into treatment groups (week 0).

A randomization scheme in REDCap (69) assigned the participants with equal probability to the exercise intervention group (EIG) or a wait-list control group (WCG) (EIG: n = 41, WCG: n = 41). For feasibility reasons, randomization was performed at the family level, meaning eligible siblings in a family were assigned to the same treatment group. The randomization sequence was generated by L.C.B. and uploaded to REDCap project and data management software. Participants were enrolled by S.R. At the end of the 12-week intervention period, both the EIG and the WCG completed the same HRQoL and Self-Concept surveys as at baseline through REDCap (week 12). Additionally, both groups wore the accelerometer again for 7 consecutive days at follow-up (week 12). The same procedures as those performed during baseline assessments, such as screening of physical activity data and re-wearing the accelerometer in case of insufficient wear, were followed during follow-up assessments. The flow of participants through the study has been shown in a CONSORT diagram (Figure 2).

Intervention

Exercise Intervention group (EIG)

The ACTIWEB-PA exercise intervention was developed in accordance with the Supportive, Active, Autonomous, Fair, and Enjoyable (SAAFE) framework for physical activity program delivery for children and adolescents, developed by Lubans et al. in 2017 (70). The SAAFE framework has been informed by the self-determination theory (71). Previously reported details describe how the components of the framework informed our intervention (106).

The participants in the EIG received an exercise program via the UNICEF Kid Power (https://www.unicefkidpower.org/) web platform for a duration of 12 weeks (107). The UNICEF Kid Power website offers a range of videos, including sport and fitness, dance, and yoga videos for children. The videos feature models performing the movements, which children can actively follow along. The movement integration videos on the UNICEF Kid Power website were categorized as high-energy dance, moderate-energy dance, and sport and fitness videos (Fig 1) based on the level of energy expenditure. The sport and fitness videos aimed to elicit at least moderate energy expenditure and focused on teaching sport skills like basketball and martial arts, while also including strength-building exercises such as push-ups, squats, and jumps. Participants in the EIG were given instructions to select a minimum of 5 exercise videos per day from a pool of over 50 options across these 3 categories. These videos, which are approximately 4 minutes in length on average, were expected to provide nearly 20 minutes of moderate to vigorous physical activity (MVPA) per day, contributing to the recommended daily target of $\geq$ 60 minutes of MVPA (60). Participants were free to accumulate the MVPA using the videos in short bouts throughout the day and on any 5 days in a week. Participation in the intervention was not supervised by the research team, was self-directed, and took place at participant homes.

Parents and caregivers were instructed to provide adequate space and a digital device for the participating child's exercises at home. They were also expected to assist the child in resolving any technical or internet-related issues that may arise during the program. To promote adherence to and retention in the exercise intervention, a weekly email was sent to the parents as a reminder to encourage the participating child to undertake the assigned physical activity. The email included web links to evidence-based articles on the importance of physical activity in children, as well as reminders to complete weekly exercise logs and surveys. The exercise intervention also incorporated a distinctive feature—an inbuilt philanthropic incentive system on the website. Children who completed the assigned videos earned virtual 'coins' that could be spent towards a local cause such as planting trees and delivering food to other families. While this was an optional component, it was hoped that this unique incentive system would help promote adherence and engagement.

Waitlist control group (WCG)

During the 12-week treatment duration, participants in the WCG continued to perform physical activity as usual. To keep them engaged with the trial, the parents in the WCG received a weekly email newsletter containing web-links to evidence-based articles on healthy dietary practices in children. The newsletters did not provide information on physical activity. However, at the end of the 12-week follow-up period, the WCG was offered the exercise intervention. All materials related to the delivery of the exercise intervention were mailed or emailed to the participants based on their preference.

Measures

Participant characteristics

The following information on participants' background characteristics was collected with a parent-reported survey at baseline: child's demographics (age, gender, race, and ethnicity), socioeconomic status (household income), anthropometrics (parent-reported height and weight), and parent characteristics (highest educational level and self-reported physical activity).

Primary outcomes

Physical activity: Participants were instructed to wear the ActiGraph GT3X+ BT accelerometer on the waist over the right hip using an elasticized belt during all waking hours for 7 consecutive days at baseline and at 12-weeks. The device was only removed during water-based activities, such as swimming and showering. Upon completion of wear, the accelerometers were returned to the research team for data processing with the ActiLife software. Data were collected in 5-second epochs and aggregated into 60-second files for wear time validation and processing. Wear time validation was conducted using the Choi algorithm which considers non-wear time as a minimum of 90 minutes of 0 counts/minute with an allowance of 2 min of interruptions plus two 30 minute windows of 0 counts/minute before and after that allowance (108). We further set the minimum wear time per day as 10 hours and the minimum days of valid wear as 5 days (109). Participants who did not meet these criteria were asked to re-wear the accelerometers for another 7 consecutive days.

Following wear time validation, the raw accelerometer activity counts were classified into different physical activity intensities using the Pulsford activity counts calibrated for hip placement in children (110). The Pulsford activity counts were chosen to classify the intensities, as the mean age in our study sample closely matched that of the calibration study by Pulsford et al. Additionally, the free-living activities performed by the children in this calibration study closely resembled the physical activity conducted as part of the exercise intervention in our study (110). Other calibration studies either had children performing lab-based physical activities such as treadmill run (111) or had a significantly different age range of participants (112,113). In Pulsford et al.'s intensity classification, sedentary behavior was defined as < 100 counts/min, while light, moderate, and vigorous physical activity were defined as ≤ 2240, ≤ 3840, and ≥ 3841 counts/min, respectively. The aggregated validated count data was then processed through the ActiLife software where these specifications were applied, and minutes spent in various activity intensities were obtained. The fully processed activity data was subsequently imported as summary files for data analyses.

Secondary outcomes

HRQoL: HRQoL was measured with the child-reported, 23-item Pediatric Quality of Life Inventory (PedsQL) Generic Core Scale (114). PedsQL assesses four dimensions of

HRQoL: physical functioning (8 items), social functioning (5 items), emotional functioning (5 items), and school functioning (5 items). The latter three dimensions are aggregated to create a 'Psychosocial health summary score.' The 'Physical health summary score' which is the same as the dimensional physical functioning score was also obtained. The total score, summary scores, and the dimensional scores are all interpretable. Participants answered each item on a 5-point Likert scale ranging from 0 (Never) to 4 (Almost always). Items are reversed scored and linearly transformed to a 0-100 scale, where higher scores indicate better HRQoL. PedsQL was an ideal choice because it addressed a broad range of HRQoL domains relevant to children and has been validated for self-report by children 8 years and older (115).

Self-Concept: Self-Concept was measured with the child-reported, 58-item Piers-Harris Children's Self-Concept Scale, third edition, validated for self-report by children 6 years and older (116). The Piers-Harris scale consists of the total Self-Concept score, which is a general measure of the child's overall Self-Concept, and 6 domain scales, which assess specific components of Self-Concept. The six subscales are: (a) behavior adjustment (10 items), (b) freedom from anxiety (8 items), (c) happiness and satisfaction (11 items), (d) intellectual and school status (12 items), (e) physical appearance and attributes (6 items), (f) and social acceptance (11 items). Reponses to each individual item on the scale were collected in a binary format (Yes/No). Items were scored 1 if the respondent answered 'yes' to a question reflecting greater Self-Concept (e.g., 'I am easy to get along with') and 'no' to a question reflecting lower Self-Concept (e.g., 'I am not popular'). Conversely, items were scored 0 if the respondent answered 'no' to a question reflecting greater Self-Concept and 'yes' to a question reflecting lower Self-Concept. Summing these scores provided the raw total and dimensional scores. The raw scores were subsequently transformed into standardized t-scores, which ranged from 26 to

71 for the total score, 26 to 58 for behavioral adjustment, 28 to 62 for freedom from anxiety, 26 to 57 for happiness and satisfaction, 26 to 61 for intellectual and school status, 26 to 57 for physical appearance and attributes, and 26 to 58 for social acceptance. Higher scores on these t-scores indicated a greater Self-Concept.

Data Analyses

The means and standard deviations (SDs) were used to describe continuous variables such as sociodemographic, anthropometric, and parental factors. For categorical variables, absolute numbers and percentages were used. Mean changes in the outcome variables in both the treatment groups from baseline to 12-weeks are reported along with the effect sizes (Cohen's d) and their 95% confidence intervals (CIs). A subgroup analysis by gender was performed only for the primary outcome variables (accumulated physical activity), where gender specific mean changes and effect sizes with 95% CIs were reported.

Mixed models were used to examine intervention effects on the primary outcomes (accumulated physical activity) and the secondary outcomes (HRQoL and Self-Concept). Mixed models effectively account for within subject (repeat measurements) and between subject variations (clustered observations) (117). In addition, these are also robust to any between group baseline imbalances in the outcome variables. We used intention to treat principle to estimate intervention effects. All participants with valid baseline outcome data were included in the analyses without performing imputations as mixed modeling accounted for missing observations in our study (118).

Our model was unadjusted and contained fixed effects of timepoint, and the interaction between group and timepoint only. The model did not include a main effect for the group, assuming that the true mean difference between the groups at baseline is 0 and any observed differences were due to chance alone (119). This modeling approach effectively addresses the issue of regression to the mean, particularly when there is potential imbalance between the groups at baseline (120). Further, we included a family variable as a random effect in our analyses to account for potential clustering of observations due to siblings from the same families. We did not adjust for covariates as relevant confounders (e.g., age, gender, income, race, and BMI) were similar between groups at baseline. Adjusting for baseline covariates in mixed modeling can also improve precision, but in our case, with a small sample size, such adjustments could lead to instability and over-specification of the models (121). Baseline accelerometer wear-time (accelerometer derived variables) which has been adjusted in previous research (122,123), was found to be nearly identical between the treatment groups. Therefore, we did not adjust it in our analysis. The treatment effects (regression coefficients) reported are for group and timepoint interaction (group*timepoint), are unstandardized, and accompanied by 95% CIs. A probability level of 0.05 was used for all statistical tests. All analyses were performed in SAS 9.4 software (SAS, Cary, North Carolina).

Results

Participant characteristics

In the ACTIWEB-PA study, 82 participants were randomized into two treatment groups, EIG (n = 41) and WCG (n = 41), as shown in the CONSORT diagram (Figure 2). The baseline characteristics of the study participants are presented in Table 1, both for the entire sample and separately for the treatment groups. The participants had a mean age of 9.2±1.1 years and 51.2% were females. The sample was mostly composed of white individuals (76.8%) and of non-Hispanic or Latino ethnicity (87.8%). The majority of participant families (57.3%) had an annual household income of at least $100,000. About 40% of the participants were classified as overweight or obese. Over 90% of mothers and 80% of fathers had an undergraduate degree or higher. Almost a quarter of parents (mothers: 24.4%, fathers: 23.4%) met the recommended weekly MVPA of $\geq$ 150 minutes. The means and SDs of the primary and secondary outcomes at baseline are summarized in Table 2. The means of all primary outcome variables, which represented accumulated physical activity, appeared to differ between the groups. Specifically, the WCG exhibited higher levels of physical activity at baseline compared to the EIG.

Changes in physical activity

Based on exploratory analyses unadjusted for baseline differences in outcomes, the movement integration intervention was found to be associated with small intervention effects for select accelerometer-measured physical activity variables (Table 3). Specifically, sedentary time decreased by 19±75 minutes/day in the EIG relative to an increase of 4±76 minutes/day in the WCG and was associated with a small effect size (*d* = -0.30, 95% CI: -0.77, 0.19) (124). The EIG showed an increase in their daily minutes of total physical activity by 12±63, while the WCG showed an increase of 4±72 minutes/day (*d* = 0.12, 95% CI: -0.36, 0.60). The EIG also showed an increase of 13±61 minutes/day of light physical activity, compared to 0.7±63 minutes/day in the WCG (*d* = -0.19, 95% CI: -0.29, 0.67). Modest improvements in steps/day were also observed (EIG: 1110±1995 vs WCG: 788±2781) (*d* = 0.13, 95% CI: -0.35, 0.61). Total minutes/day spent in MVPA did not see improvements in response to the intervention (EIG: -0.3±19 vs WCG: 3 ±26) (*d* = -0.16, 95% CI: -0.64, 0.32).

Gender-specific exploratory comparison of means (Table 4) showed differential changes in physical activity outcomes in boys and girls. Improvements in mean accumulated physical activity outcomes in EIG were greater for girls compared to boys. Specifically, in girls, four outcomes; minutes/day of total physical activity (*d* = 0.24, 95% CI: -0.37, 0.84), light physical activity (*d* = 0.33, 95% CI: -0.28, 0.93), sedentary time (*d* = -0.35, 95% CI: -0.95, 0.27), and steps/day (*d* = 0.29, 95% CI: -0.32, 0.90) were associated with small effect sizes compared to boys in whom only one outcome, minutes/day of sedentary time (*d* = -0.22, 95% CI: -0.84, 0.42) was associated with a small effect size.

Results from mixed modeling that adjusted for baseline differences in physical activity outcomes and missing data are shown in Table 5. EIG showed a non-significant reduction in sedentary time by 5.8 minutes/day (95% CI: -39.7, 28.0, $p = 0.7$), non-significant increase in light physical activity by 5.4 minutes/day (95% CI: -21.6, 32.4, $p = 0.7$), and a non-significant decrease in MVPA by 8.5 minutes/day (95% CI: -18.7, 1.7, $p = 0.1$).

Changes in HRQoL and Self-Concept

Table 3 displays the mean changes in the secondary outcomes of HRQoL and Self-Concept from baseline to follow-up for both the EIG and the WCG, along with the corresponding effect sizes based on exploratory analyses. There were no meaningful improvements in the HRQoL measures in the EIG as measured by PedsQL except physical health summary score/physical functioning which was associated with a small effect size (*d* = 0.20, 95% CI: -0.25, 0.64). Overall Self-Concept as measured by the Piers Harris scale did not show improvements in response to the intervention. However, two subscales, namely behavioral adjustment, and intellectual and school status, demonstrated improvements in the EIG and were associated with a medium effect size (*d* = 0.62, 95% CI: 0.12, 1.11) and a small effect size (*d* = 0.40, 95% CI: -0.18, 0.96), respectively. Results from mixed models (Table 5) that adjusted for baseline imbalances in secondary outcomes and missing data, revealed that the exercise intervention did not result in significant improvements in either HRQoL or Self-Concept except the behavioral adjustment subscale of the Piers Harris Self-Concept scale ($\beta = 3.3$, 95% CI = 0.3, 6.2, $p = 0.03$).

Discussion

In the ACTIWEB-PA study, using a pilot randomized controlled design, we examined the preliminary intervention effects of a novel, web-based movement integration program for children, delivered unsupervised, remotely in a home setting. Adjusting for baseline imbalances in the outcomes, results demonstrated that the web-based intervention was ineffective in improving the physical activity outcomes of the children. In addition, among the secondary outcomes, no intervention effects for HRQoL and most Self-Concept measures were observed. Despite the lack of significant findings, this study serves as a valuable initial step in the evaluation of remotely delivered movement integration programs for children. The insights gained from this study provide a foundation for future research in this area, guiding the development and refinement of future eHealth interventions to promote physical activity in children.

The non-significant intervention effects on primary outcomes in our study are unsurprising. Behavioral interventions to promote physical activity in children are typically associated with small effects (125). In Metcalf et al.'s seminal meta-analysis that included studies with an RCT design and accelerometer measured outcomes, a pooled increase of only 4 minutes/day in total physical activity of children was obtained (125). Meta-analytic and scoping reviews focusing specifically on eHealth physical activity interventions for youth have yielded mixed evidence as well. Some reviews have reported small improvements in certain physical activity outcomes, while others have found no significant effects (31,126–128). However, it is important to acknowledge that these reviews that focused on eHealth interventions exhibited significant heterogeneity and encompassed studies with different characteristics compared to our study. These variations included differences in study design, participants, intervention type, duration, delivery methods, and measurement of physical activity outcomes, among other factors. Due to the limited research on movement integration programs, there are no comparable studies available to directly contrast our results with.

The ineffectiveness of the current intervention in improving children's physical activity levels can be attributed to several factors. Previous research suggests that self-directed, remotely delivered eHealth exercise interventions, where participants have discretion over their exercise participation, may experience inconsistent implementation fidelity (78). While we monitored the completion of weekly exercise videos, which indicated an overall high adherence to the program[3] (106), there are uncertainties regarding how participants engaged with the videos in the absence of direct supervision. To promote implementation fidelity in future research, measures such as enhanced parent engagement with frequent check-ins can be implemented (129).

Furthermore, while the exercise prescription in our intervention was based on SAAFE principles informed by the self-determination theory (70), the web platform used to deliver the exercise videos did not incorporate specific behavior change strategies, such as social comparison, goal setting, self-monitoring, and performance feedback (130). Previous evidence suggests that eHealth interventions that incorporate a higher number of behavior change strategies are more likely to be effective in achieving desired outcomes (131). In the ACTIWEB-PA study, we utilized an off-the-shelf, freely accessible web platform for intervention delivery due to practical considerations. However, for future investigations, we recommend the use of

[3] In a previous feasibility evaluation of ACTIWEB-PA, 69% (n = 25) participants had high adherence, meaning they completed $\geq$ 70% of total prescribed videos (106). This adherence was found to be superior to comparable evidence (78).

web-based platforms specifically designed to deliver the movement integration intervention. This platform should incorporate relevant behavior change techniques *a priori* to optimize its effectiveness.

The anticipated changes in physical activity outcomes in our study were expected to occur not only through increased activity levels during the web-based exercises but also through transfer effect, leading to changes in overall activity (132). This transfer effect was hypothesized to be facilitated by increased awareness and dialogue on physical activity behavior within participant homes (106). However, contrary to expectations, the transfer to overall physical activity did not occur as anticipated, and we even observed non-significant reductions in participant MVPA. One possible explanation for this unexpected finding is that the use of digital devices to access the exercise program inadvertently promoted and normalized increased screen time among families participating in the intervention. This unintentional increase in screen time, which could have been used for physical activity instead, may have contributed to lower overall physical activity levels, as evidenced by decrease in MVPA observed in the intervention group. Another potential explanation for the lack of transfer effect on overall physical activity is that children may have perceived intervention participation as contributing to their overall physical activity. Consequently, they could have replaced their usual similarly intense physical activities with intervention-based exercises. This substitution effect could have led to a balance or no net increase in overall physical activity levels (125). However, it is important to note that these are speculative explanations, and additional research is necessary to investigate the potential substitution effect and whether increased screen time resulting from the use of digital interventions can offset the positive effects on physical activity.

Through exploratory analyses, a gender disparity in the intervention effects on primary outcomes was observed, with girls exhibiting higher improvements in physical activity outcomes compared to boys. Previous meta-analytic reviews on eHealth exercise interventions in children were unable to conduct gender-specific analyses due to limited studies (31,126). However, evidence from non-eHealth, traditional physical activity interventions suggests that girls may respond more positively (133,134). The observed difference in our study may be attributed to lower baseline physical activity levels in girls compared to boys. However, it is important to note that these results are preliminary, as the small sample size prevented us from conducting interaction analyses by gender using mixed modeling. Further research is necessary to establish evidence regarding gender differences in the effects of eHealth physical activity interventions in children.

Among the secondary outcomes, our intervention was associated with improvement in behavioral adjustment subscale of the Piers Harris Self-Concept scale that measures admission or denial of problematic behavior at home or school (116). However, it is unclear why improvements in only one sub-scale are observed in our study. In terms of overall and dimensional HRQoL and overall self-concept, our intervention did not yield significant effects. Previous evidence in this area has shown mixed results, with some physical activity interventions in children and adolescents demonstrating small increases in overall self-concept (100,135), while others have reported null effects (136–138).

The null effects on psychosocial outcomes in our study can be attributed to the lack of changes in the primary outcomes, which were expected to serve as mechanism for influencing psychosocial health. Since the intended changes in the primary outcomes did not occur, the expected impact on psychosocial health did not manifest, resulting in null effects on those outcomes. This observation is consistent with findings from other comparable studies, which have also reported no significant changes in physical activity outcomes and, consequently, no changes in psychosocial health of children (137,139). Another possibility is that we had a lower dose of physical activity than what may be necessary to induce changes in psychosocial health outcomes (6,137). Research suggests that interventions prescribing over 60 minutes/day of MVPA were associated with improved mental health outcomes in children (6). Given the high overall adherence to the exercise prescription observed in our study (106), there is merit in considering an increase in the prescribed MVPA exposure to 60 minutes/day in future trials of eHealth interventions aiming to target changes in children's psychosocial health.

Strengths and Limitations

The ACTIWEB-PA pilot study adds to the scant evidence base of youth-targeted eHealth exercise programs in general and movement integration programs in particular. To the best of our knowledge, this study is the first to evaluate the preliminary intervention effects of a web-based, youth-targeted movement integration program delivered remotely at home. Taking advantage of children's widespread internet and digital device usage, the study is both timely and relevant. The findings provide valuable insights for remotely delivered RCTs targeting digital-native children in behavioral interventions. Additionally, they inform sample size estimation for future definitive trials in this field. The study's strength lies in its rigorous randomized controlled design and the use of direct measures used to assess physical activity outcomes.

However, there are some limitations that should be considered. The sample in this study was homogenous, predominantly consisting of white, affluent participants from a specific region in the mid-western United States. Therefore, the generalizability of the results to other populations may be limited, as socioeconomic status (140) and geography (141) can influence study outcomes. Further, as this study was a pilot evaluation, the intervention effects should be interpreted cautiously and seen as preliminary indications rather than definitive conclusions. Future adequately powered trials, able to prevent type II error (142) will be needed to provide more robust evidence on the effectiveness of movement integration programs. Finally, we acknowledge the presence of imbalances between the treatment groups in the study outcomes at baseline, which could have potentially influenced the validity of our findings due to regression to the mean (120). These imbalances occurred by chance and were unrelated to treatment allocation. However, we effectively addressed these imbalances through statistical methods, utilizing mixed models to adjust for the baseline variations between the groups. Despite the initial imbalances, our study design and statistical analyses methods ensured a robust evaluation of the intervention effects.

Conclusion

The ACTIWEB-PA study was a 12-week pilot evaluation of a remotely delivered web-based movement integration intervention for children. Using a randomized controlled design, we assessed the intervention's effects on accelerometer measured physical activity and self-reported psychosocial health. After adjusting for baseline differences, the intervention did not significantly improve physical activity outcomes. Our results were indicative of a gender-based variation in physical activity outcomes, which should be further explored in future trials with effect modification analysis. No significant effects were found on HRQoL and most Self-Concept outcomes. To enhance intervention effects, we recommend increasing prescribed MVPA dosage to 60 minutes/day, improving intervention fidelity, and utilizing a web platform with integrated behavior change strategies. Overall, the ACTIWEB-PA pilot study provides valuable insights for optimizing future definitive trials investigating the effectiveness of remotely delivered eHealth exercise programs for children.

Figure 1: A screenshot of the available exercise videos on UNICEF Kid Power website.

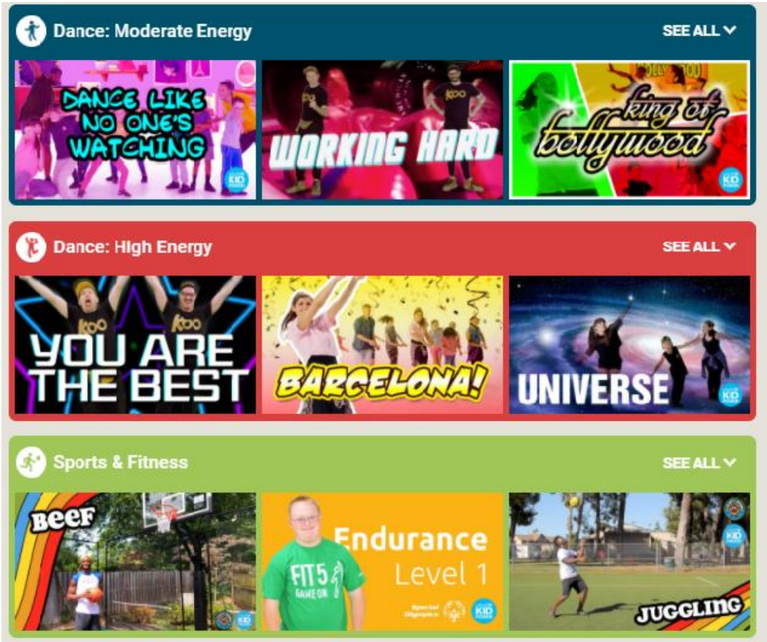

Figure 2: CONSORT Diagram

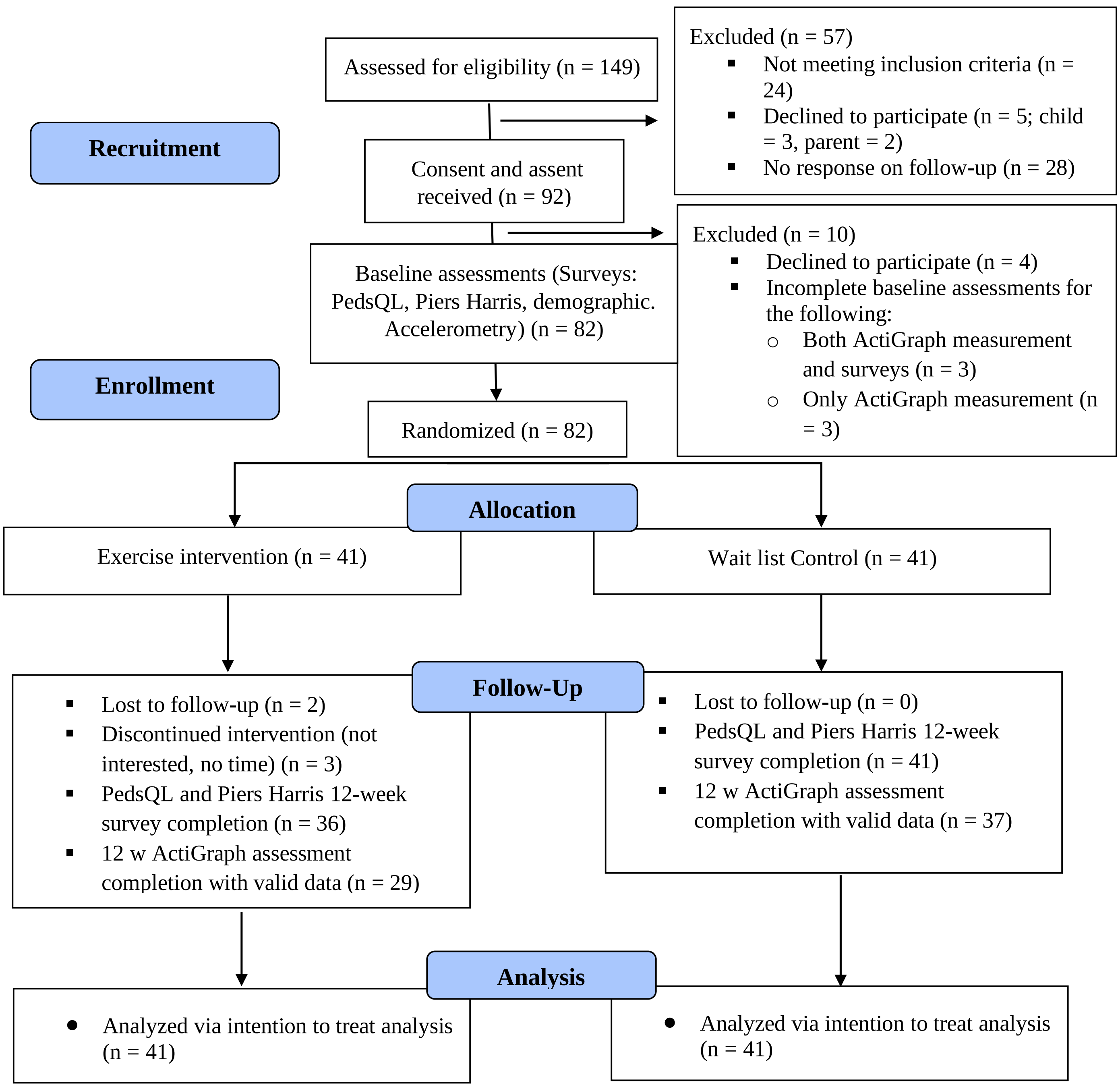

Table 1: **Baseline characteristics of children.**

	Total	**Exercise Intervention**	**Wait-list control**
	Mean (SD) or N (%)	Mean (SD) or N (%)	Mean (SD) or N (%)
N	82	41	41
Sociodemographic characteristics			
Age	9.2 (1.1)	9.4 (1.0)	9.1 (1.2)
Gender			
Male	39 (47.6%)	20 (48.8%)	19 (46.3%)
Female	42 (51.2%)	20 (48.8%)	22 (53.7%)
Other	1 (1.2%)	1 (2.4%)	-
Race			
White	63 (76.8%)	33 (80.5%)	30 (73.2%)
Black	6 (7.3%)	4 (9.8%)	2 (4.9%)
Asian	10 (12.2%)	4 (9.8%)	6 (14.6%)
Others	3 (3.7%)	-	3 (7.3%)
Ethnicity			
Hispanic or Latino	9 (11%)	3 (7.3%)	6 (14.6%)
Not Hispanic or Latino	72 (87.8%)	38 (92.7%)	34 (82.9%)
Prefer not to answer	1 (1.2%)	-	1 (2.4%)
Annual Household Income			
<$100,000	26 (31.7%)	13 (31.7%)	13 (31.7%)
$100,000-199,999	35 (42.7%)	17 (41.5%)	18 (43.9%)
≥$200,000	12 (14.6%)	6 (14.6%)	6 (14.6%)
Prefer not to answer	9 (11%)	5 (12.2%)	4 (9.8%)
Anthropometric characteristics			
BMI			
Healthy weight	47 (57.3%)	22 (53.7%)	25 (61.0%)
Underweight	3 (3.6%)	1 (2.4%)	2 (4.9%)
Overweight	14 (17.1%)	6 (14.6%)	8 (19.5%)
Obese	18 (22%)	12 (29.2%)	6 (14.6%)
Parental characteristics			
Mother's highest education			
High School	4 (4.9%)	2 (4.9%)	2 (4.9%)
Undergraduate	44 (53.7%)	21 (51.2%)	23 (56.1%)
Graduate	34 (41.5%)	18 (43.9%)	16 (39.0%)
Father's highest education			
High School	11 (14.3%)	8 (21.1%)	3 (7.7%)
Undergraduate	34 (44.2%)	20 (52.6%)	14 (35.9%)
Graduate	32 (41.6%)	10 (26.3%)	22 (56.4%)
Mother's self-reported weekly MVPA (minutes)			
>60	32 (39%)	15 (36.6%)	17 (41.5%)
60-89	15 (18.3%)	9 (22.0%)	6 (14.6%)
90-149	15 (18.3%)	4 (9.8%)	11 (26.8%)
≥150	20 (24.4%)	13 (31.7%)	7 (17.1%)
Father's self-reported weekly MVPA (minutes)			
>60	25 (32.5%)	10 (26.3%)	15 (38.5%)

60-89	21 (27.3%)	10 (26.3%)	11 (28.2%)
90-149	13 (16.9%)	7 (18.4%)	6 (15.4%)
≥150	18 (23.4%)	11 (29.0%)	7 (18.0%)

Notes: BMI has been age and sex standardized based on CDC guidelines. The cut-offs are based on CDC growth charts (<5 kg/m^2: underweight, ≥5 kg/m^2 and <85 kg/m^2: healthy weight, ≥85 kg/m^2 and <95 kg/m^2: overweight, ≥95 kg/m^2: obese).

Table 2: Differences in primary and secondary outcome variable means at baseline.

	Total	**Exercise Intervention**	**Wait-list control**
	Mean (SD)	Mean (SD)	Mean (SD)
Accumulated Physical Activity			
Total physical activity (mins/day)	385 (74)	366 (73)	403 (71)
MVPA (mins/day)	40 (28)	33 (27)	46 (27)
Light physical activity (mins/day)	345 (59)	333 (62)	357 (55)
Sedentary time (mins/day)	430 (85)	452 (91)	409 (74)
Steps/day	8080 (2638)	7287 (2653)	8872 (2401)
HRQoL			
Total score	79.7 (13.1)	78.9 (15.1)	80.5 (10.9)
Physical Health Summary Score	83.8 (13.5)	83.7 (15.9)	83.9 (10.9)
Psychosocial Health Summary Score	77.48 (14.2)	76.3 (16.1)	78.7 (12.1)
Subscales			
Physical Functioning	83.8 (13.6)	83.7 (15.9)	83.9 (10.9)
Emotional Functioning	69.7 (17.3)	67.4 (19.3)	71.9 (15.0)
Social Functioning	84.0 (17.5)	83.5 (18.9)	84.4 (16.2)
School Functioning	78.8 (15.2)	77.9 (17.9)	79.8 (12.1)
Self-Concept			
Total Self-Concept score	51.7 (7.9)	50.5 (8.6)	52.7 (6.5)
Subscales			
Behavioral adjustment	51.6 (9.1)	49.6 (8.8)	53.7 (5.4)
Intellectual and School Status	54.7 (5.5)	52.7 (10.8)	56.8 (6.3)
Physical appearance and attributes	52.9 (7.3)	51.6 (8.0)	54.2 (6.4)
Freedom from anxiety	53.4 (7.6)	53.2 (9.8)	53.7 (8.3)
Social acceptance	43.2 (9.05)	42.0 (8.3)	44.3 (7.3)
Happiness and satisfaction	54.2 (7.5)	54.1 (6.7)	54.2 (4.2)

Notes: The PedsQL scale is used to measure HRQoL, with higher scores indicating better HRQoL. It encompasses overall scores, summary scores, and dimensional scores on a scale ranging from 0 to 100. Self-Concept is measured by the Piers Harris scale. The raw scores on this scale are transformed to standardized t-scores, which range from 26 to 71 for the total score, 26 to 58 for behavioral adjustment, 28 to 62 for freedom from anxiety, 26 to 57 for happiness and satisfaction, 26 to 61 for intellectual and school status, 26 to 57 for physical appearance and attributes, and 26 to 58 for social acceptance. Higher scores on these t-scores indicate a greater Self-Concept.

Table 3: Primary and secondary outcome means by treatment groups and effect sizes (Cohen's d).

	Exercise Intervention			**Wait list Control**			**Cohen's d (95% CI)**
	Baseline Mean (SD)	**12 weeks** Mean (SD)	**Change** Mean (SD)	**Baseline** Mean (SD)	**12 weeks** Mean (SD)	**Change** Mean (SD)	
Accumulated Physical Activity	**(N = 41)**	**(N = 31)**	**(N = 31)**	**(N = 41)**	**(N = 37)**	**(N = 37)**	
Total physical activity (mins/day)	366 (73)	389 (89)	12 (63)	403 (71)	413 (94)	4 (72)	0.12 (-0.36, 0.60)
MVPA (mins/day)	33 (27)	33 (26)	-0.3 (19)	46 (27)	52 (30)	3 (26)	-0.16 (-0.64, 0.32)
Light physical activity (mins/day)	333 (62)	356 (67)	13 (61)	357 (55)	361 (78)	0.7 (63)	0.19 (-0.29, 0.67)
Sedentary time (mins/day)	452 (91)	436 (115)	-19 (75)	409 (74)	405 (78)	4 (78)	-0.30 (-0.77, 0.19)
Steps/day	7287 (2653)	8597 (3600)	1110 (1995)	8872 (2401)	9912 (3348)	788 (2781)	0.13 (-0.35, 0.61)
HRQoL	**(N = 41)**	**(N = 36)**	**(N = 36)**	**(N = 41)**	**(N = 41)**	**(N = 41)**	
Total score	78.9 (15.1)	80.5 (15.9)	1.4 (9.4)	80.5 (10.9)	81.0 (8.9)	0.5 (8.5)	0.10 (-0.34, 0.55)
Physical Health Summary Score	83.7 (15.9)	83.6 (16.1)	0.2 (12.9)	83.9 (10.9)	81.9 (9.5)	-2.0 (9.4)	0.20 (-0.25, 0.64)
Psychosocial Health Summary Score	76.3 (16.1)	78.8 (16.9)	2.0 (8.9)	78.7 (12.1)	80.4 (10.3)	1.7 (10.3)	0.02 (-0.42, 0.47)
Subscales							
Physical Functioning	83.7 (15.9)	83.6 (16.1)	0.2 (12.9)	83.9 (10.9)	81.9 (9.5)	-2.0 (9.4)	0.20 (-0.25, 0.64)
Emotional Functioning	67.4 (19.3)	73.3 (16.9)	4.7 (14.7)	71.9 (15.0)	74.0 (16.1)	2.1 (14.4)	0.17 (-0.28, 0.62)
Social Functioning	83.5 (18.9)	84.3 (20.5)	1.0 (11.1)	84.4 (16.2)	86.4 (13.1)	2.0 (12.7)	-0.09 (-0.54, 0.36)
School Functioning	77.9 (17.9)	78.9 (19.5)	0.3 (13.4)	79.8 (12.1)	80.8 (13.4)	1.0 (14.3)	-0.05 (-0.50, 0.40)
Self-Concept							
Total Self-Concept score	50.5 (8.6) **(N = 31)**	55.3 (6.0) **(N = 23)**	0.8 (4.9) **(N = 18)**	52.7 (6.5) **(N = 36)**	54.2 (5.7) **(N = 22)**	0.9 (4.9) **(N = 19)**	-0.02 (-0.67, 0.62)
Subscales							
Behavioral adjustment	49.6 (8.8) **(N = 39)**	55.5 (4.9) **(N = 32)**	4.2 (6.8) **(N = 30)**	53.7 (5.4) **(N = 39)**	53.5 (7.0) **(N = 38)**	0.1 (6.6) **(N = 36)**	0.62 (0.12, 1.11)
Intellectual and School Status	52.7 (10.8) **(N = 40)**	58.1 (4.2) **(N = 26)**	1.4 (4.1) **(N = 25)**	56.8 (6.3) **(N = 38)**	58.6 (2.8) **(N = 25)**	0.0 (3.0) **(N = 23)**	0.40 (-0.18, 0.96)
Physical appearance and attributes	51.6 (8.0) **(N = 40)**	53.0 (8.8) **(N = 36)**	1.2 (8.7) **(N = 35)**	54.2 (6.4) **(N = 41)**	54.2 (5.7) **(N = 39)**	-0.1 (6.9) **(N = 39)**	0.16 (-0.30, 0.61)
Freedom from anxiety	53.2 (9.8) **(N = 41)**	52.7 (9.7) **(N = 36)**	0.1 (8.0) **(N = 36)**	53.7 (8.3) **(N = 41)**	54.9 (7.0) **(N = 39)**	1.1 (9.8) **(N = 39)**	-0.11 (-0.56, 0.35)
Social acceptance	42.0 (8.3) **(N = 39)**	43.3 (7.9) **(N = 35)**	1.2 (7.6) **(N = 33)**	44.3 (7.3) **(N = 41)**	44.9 (6.7) **(N = 40)**	0.4 (6.6) **(N = 40)**	0.11 (-0.35, 0.57)
Happiness and satisfaction	54.1 (6.7) **(N = 35)**	55.0 (3.6) **(N = 31)**	-0.3 (3.9) **(N = 27)**	54.2 (4.2) **(N = 38)**	53.7 (4.4) **(N = 35)**	-0.2 (4.4) **(N = 32)**	-0.04 (-0.55, 0.47)

Notes: Cohen's d is computed by dividing the difference in mean changes in the intervention and waitlist control groups by their pooled standard deviation. Physical Health Summary Score= Physical Functioning score; Psychosocial Health Summary Score = Emotional Functioning score + Social Functioning score + School Functioning score. The PedsQL scale is used to measure HRQoL, with higher scores indicating better HRQoL. It encompasses overall scores, summary scores, and dimensional scores on a scale ranging from 0 to 100. Self-Concept is measured by the Piers Harris scale. The raw scores on this scale are transformed to standardized t-scores, which range from 26 to 71 for the total score, 26 to 58 for behavioral adjustment, 28 to 62 for freedom from anxiety, 26 to 57 for happiness and satisfaction, 26 to 61 for intellectual and school status, 26 to 57 for physical appearance and attributes, and 26 to 58 for social acceptance. Higher scores on these t-scores indicate a greater Self-Concept.

Table 4: Primary (Physical Activity) outcome mean changes and effect sizes (Cohen's d) by gender.

	Exercise Intervention	**Wait List control**	
Males			
	Change Mean (SD)	**Change** Mean (SD)	**Cohen's d (95% CI)**
Accumulated Physical Activity	**N = 20**	**N = 19**	
Total physical activity (mins/day)	5 (49)	0 (71)	0.08 (-0.55,0.70)
MVPA (mins/day)	-7 (14)	-3 (30)	-0.14 (-0.77, 0.49)
Light physical activity (mins/day)	11 (55)	3 (68)	0.13 (-0.50, 0.75)
Sedentary time (mins/day)	-4 (64)	11 (70)	-0.22 (-0.84, 0.42)
Steps/day	755 (1570)	796 (3119)	-0.02 (-0.64, 0.61)
Females			
	N = 20	**N = 22**	
Total physical activity (mins/day)	26 (73)	8 (75)	0.24 (-0.37, 0.84)
MVPA (mins/day)	7 (21)	10 (21)	-0.15 (-0.75, 0.46)
Light physical activity (mins/day)	19 (67)	-2 (59)	0.33 (-0.28, 0.93)
Sedentary time (mins/day)	-34 (87)	-4 (86)	-0.35 (-0.95, 0.27)
Steps/day	1503 (2396)	780 (2506)	0.29 (-0.32, 0.90)

Table 5: Mixed model intervention effects on primary and secondary outcomes.

	Baseline	12 weeks		Intervention effect/Unstandardized regression coefficient for group*timepoint (95% CI)	*p*-value (group*time point)
		Intervention	Waitlist Control		
	Mean (SD)	Mean (95%CI)	Mean (95% CI)		
Accumulated Physical Activity					
Total physical activity (mins/day)	384 (84)	394 (368, 420)	395 (37, 419)	-0.9 (-31.4, 29.6)	0.95
MVPA (mins/day)	39 (28)	37 (28, 45)	45 (37, 53)	-8.5 (-18.7, 1.7)	0.10
Light physical activity (mins/day)	345 (66)	357 (335, 379)	352 (332, 372)	5.4 (-21.6, 32.4)	0.69
Sedentary time (mins/day)	432 (90)	420 (392, 449)	426 (399, 453)	-5.8 (-39.7, 28.0)	0.73
Steps/day	7974 (2948)	8950 (8027, 9873)	9028 (8155, 9901)	-78 (-1138, 981)	0.88
HRQoL					
Total Score	79.7 (12.9)	80.9 (77.4, 84.4)	80.3 (76.9, 83.7)	0.6 (-3.2, 4.4)	0.76
Physical Health Summary Score	83.9 (13.3)	84.0 (80.1, 87.9)	81.9 (78.2, 85.6)	2.1 (-2.5, 6.7)	0.37
Psychosocial Health Summary Score	77.5 (14.1)	79.3 (75.5, 83.1)	79.5 (75.8, 83.2)	-0.2 (-4.3, 3.9)	0.92
Subscales					
Physical Functioning	83.9 (13.3)	84.0 (80.1, 87.9)	81.9 (78.2, 85.6)	2.1 (-2.5, 6.7)	0.37
Emotional Functioning	69.7 (17.3)	74.0 (68.9, 79.1)	72.6 (67.8, 77.4)	1.4 (-4.7, 7.5)	0.65
Social Functioning	84.0 (17.2)	84.8 (80.1, 89.5)	86.1 (81.6, 90.6)	-1.3 (-6.4, 3.8)	0.61
School Functioning	78.8 (15.8)	79.0 (74.4, 83.7)	80.2 (75.8, 84.6)	-1.2 (-6.8, 4.5)	0.68
Self-Concept					
Total Self-Concept score	51.7 (7.2)	53.4 (51.0, 55.8)	52.9 (50.4, 55.3)	0.5 (-2.5, 3.5)	0.73
Subscales					
Behavioral adjustment	51.5 (5.1)	55.7 (53.3, 58.0)	52.4 (50.2, 54.5)	3.3 (0.3, 6.2)	0.03
Intellectual and School Status	54.7 (8.6)	56.3 (54.1, 58.6)	55.1 (52.8, 57.4)	1.2 (-0.8, 3.3)	0.24
Physical appearance and attributes	52.8 (7.4)	53.2 (50.8, 55.5)	53.5 (51.3, 55.8)	-0.4 (-3.5, 2.7)	0.80
Freedom from anxiety	53.4 (8.8)	53.1 (50.4, 55.8)	54.7 (52.1, 57.3)	-1.6 (-5.1, 2.0)	0.38
Social acceptance	43.2 (7.6)	44.0 (41.6, 46.3)	44.1 (41.8, 46.3)	0.1 (-3.0, 2.8)	0.95
Happiness and satisfaction	54.1 (5.1)	54.4 (52.8, 56.0)	53.8 (52.2, 55.3)	0.6 (-1.4, 2.6)	0.54

Notes: Regression coefficients and *p* values are from mixed models with fixed effects of timepoint and interaction of group with timepoint. Additionally, family was a random effect in the models. The PedsQL scale is used to measure HRQoL, with higher scores indicating better HRQoL. It encompasses overall scores, summary scores, and dimensional scores on a scale ranging from 0 to 100. Self-Concept is measured by the Piers Harris scale. The raw scores on this scale are transformed to standardized t-scores, which range from 26 to 71 for the total score, 26 to 58 for behavioral adjustment, 28 to 62 for freedom from anxiety, 26 to 57 for happiness and satisfaction, 26 to 61 for intellectual and school status, 26 to 57 for physical appearance and attributes, and 26 to 58 for social acceptance. Higher scores on these t-scores indicate a greater Self-Concept.

Chapter 4 - Aim 3: SHOW data manuscript 3

Title: Correlates of accelerometer measured physical activity and sedentary behavior of children and adolescents: Results from Survey of Health of Wisconsin.

Abstract

Introduction: Research on the correlates of physical activity and sedentary behavior in children and adolescents using direct assessment is limited. It is essential to identify the factors associated with activity achievement in this population to better inform future health promotion interventions and target specific sub-groups in need. This study undertakes a comprehensive evaluation of the correlates of accelerometer measured minutes/day of moderate to vigorous intensity physical activity (MVPA) and sedentary bouts of children and adolescents.

Methods: Data for 6–17-year-olds (n = 308) who fulfilled the accelerometer wear time requirements in wave II of Survey of Health of Wisconsin (SHOW) were used in the current study. Information on potential correlates including, sociodemographic, anthropometric, neighborhood, screen-time, and parental factors was collected via self-report or proxy-report from parents/caregivers in SHOW. Physical activity and sedentary behavior were measured by ActiGraph GT3X+ BT accelerometer worn on the wrists of the children and adolescents for 7 consecutive days. Multilevel linear mixed modeling was used to examine the associations between the potential correlates and the outcomes; average minutes/day of MVPA and sedentary bouts.

Results: A higher duration of screen time in children and adolescents was associated with a non-significant reduction in MVPA (β = -12.5, 95% CI = -25.6, 0.6, $p = 0.06$). Similarly, Walk Score showed a non-significant negative association with MVPA (β = -0.2, 95% CI = -0.4, 0.0, $p = 0.09$). Among the demographic correlates, boys accumulated non-significantly fewer minutes in sedentary bouts compared to girls (β = -11.25, 95% CI = -26.8, 4.3, $p = 0.16$). In addition, higher BMI was associated with significantly higher time in sedentary bouts (β = 0.3, 95% CI = 0.0, 0.5, $p = 0.04$).

Conclusion: Through our analyses, we identified several important correlates of accelerometer measured MVPA and sedentary bouts in children and adolescents, including the modifiable factor of screen time. These findings provide valuable insights to inform the framing of future interventions aimed at promoting physical activity and reducing sedentary behavior in children and adolescents. These results also underscore the importance of targeting specific subgroups, such as girls and overweight/obese children and adolescents, in interventions addressing physical activity and sedentary behavior.

Introduction

The health-enhancing benefits of physical activity in children and adolescents are well researched (1). The current federal and international physical activity guidelines recommend that children and adolescents perform 60 minutes or more of daily moderate to vigorous intensity physical activity (MVPA), including muscle strengthening, and bone strengthening exercises (60,143). However, achievement is low, with just a quarter of the young population meeting the recommendations (144). Even those children and adolescents who are physically active can have high amounts of sedentary time (145). Sedentary time is defined as waking time spent in a sitting/lying posture with low energy expenditure (< 1.5 METs) and includes most screen time as well as time spent sitting while at school, in the car, eating, relaxing, or other seated activities (146). Data from 2015-16 NHANES survey showed that two-thirds of the young population in the United States engaged in more than 2 hours of screen time in a day (144). This combination of low physical activity and high sedentary time in the young presents a major public health concern. It is associated with an increased risk of obesity, cardiovascular disease, type 2 diabetes, and other chronic diseases (1). To enhance physical activity and reduce sedentary behavior in children and adolescents, effective interventions are needed. Investigating the determinants of these behaviors will inform the framing and delivery of interventions, addressing disparities and tailoring them to meet the unique needs of this population.

A large body of research has examined the determinants of physical activity in children and adolescents (39–44). Socioeconomic and demographic factors are the most notable determinants of physical activity outcomes (147). For instance, physical activity levels decrease with age, with only 5% of 16-19-year-olds meeting the physical activity recommendations compared to 42.5% of 6-11-year-olds (144). In addition, girls as compared to boys are less physically active and this gap widens as they age (39,144). Physical activity levels are also lower among children and adolescents from racial/ethnic minorities, poorer households, and urban areas (147–150). Differences in physical activity are also dependent on neighborhood correlates such as access to “activity-friendly environments” and perceptions of neighborhood safety (39,151). Parental characteristics, including parental engagement in physical activity and their emotional and physical health, constitute another category of variables that influence activity levels in children and adolescents (45,152). In addition to physical activity behaviors, notable disparities in sedentary behavior exist among children and adolescents. Factors such as age, sex, paternal education, and race/ethnicity (48,49,144) play a significant role in shaping sedentary behavior patterns in this population. The availability of neighborhood green spaces, walking infrastructure, and parks are associated with screen time, which is used as a proxy indicator for sedentary time (46,47,153). Furthermore, parental characteristics, including sedentary behavior, screen time, and family functioning/parental depression, are associated with higher levels of sedentary behavior among children and adolescents (45,49).

While research on the factors that influence physical activity and sedentary behavior in children and adolescents has increased, there are still gaps in the literature. Specifically, there are fewer studies examining the correlates of sedentary behavior than physical activity (48). Due to limited empirical evidence, reviews have not been effective in summarizing the findings and drawing conclusions about potential correlates of sedentary behavior in this population (48,50). In addition, the use of device-based measurements in physical activity epidemiology in children and adolescents has accelerated only relatively recently (52,53). Therefore, the majority of evidence is still based on subjective measurement tools (43,49), which are prone to threats to validity such as misclassification bias and recall bias (51). Therefore, more research is needed to investigate the determinants of physical activity and sedentary behavior in children and adolescents with directly measured outcomes to strengthen the existing evidence.

To this end, the purpose of this study was to fill the gaps in research by comprehensively examining potential correlates of accelerometer-measured physical activity and sedentary behavior in children and adolescents aged 6-17 years. Specifically, we investigated the demographic, socioeconomic, screen-time, parental, and neighborhood factors using data from wave II of SHOW (59). It was hypothesized that meaningful associations between the potential correlates and activity outcomes would be observed.

Methods

Description of the survey and dataset

Since 2008, as part of Survey of Health of Wisconsin (SHOW), annual cross-sectional health surveys enrolling a representative sample of non-institutionalized, civilian Wisconsin residents have been conducted. Wave I of the survey, conducted between 2008 and 2013, focused only on collecting data from adults and utilized a two-stage probability sampling strategy involving census blocks and households (154). Wave II of SHOW, conducted from 2014 to 2016, implemented a three-stage sampling design involving counties, census blocks, and households. In this wave, data were collected from both adults and minors for the first time (59). A total of 1,957 adults and 645 children and adolescents were surveyed. For the current study, only the data for individuals aged 6 to 17 years from wave II were utilized.

Wave II of SHOW collected self-reported or proxy-reported information on demographic factors, socio-economic determinants, physical and built environment, health history, health care, and health-related behaviors (e.g., sleep, diet, physical activity) for the entire sample. Additionally, clinical measurements (e.g., height, weight, and waist and hip circumference) were taken for participants aged 3 years and older, while blood biomarkers (e.g., CBC, HbA1c, glucose) and bio samples (e.g., serum, plasma, urine) were collected for participants aged 18 years and older. Wave II also utilized accelerometers to collect 7-day data on physical activity, sedentary behavior, and sleep for children and adolescents, as well as for adults.

Accelerometry considerations

Children and adolescents in wave II of SHOW wore the ActiGraph GT3X+ BT accelerometer on their non-dominant wrists for 7 consecutive days and only removed the device during water-based activities such as swimming and showering. The data were downloaded by SHOW research team upon return of accelerometers and processed with ActiLife software. Data collected in 1-second epochs were aggregated into 60-second files for processing. The processing of the 60-second raw dataset was performed in three steps.

In the first step, to exclude sleep periods from the raw data, sleep period detection and scoring were performed using Tudor-Locke and Cole-Kripke algorithms respectively (155,156). In the second step, wear time validation was performed as part of which, sleep periods were marked as non-wear times and valid wear time was defined using Troiano's (2007) parameters. According to these parameters, nonwear time was defined as intervals of at least 60 consecutive minutes of zero counts, with allowance for up to 2 consecutive minutes of observations of 1-100 counts/minute. Periods of nonwear were defined as ending when count levels exceeded 100 counts/minute or when 3 consecutive minutes of observation were between 1 and 100 counts/minute (157). Further, valid wear time was defined as at least 600 minutes/10 hours of wear on at least 3 days (109). In the third and final step, activity counts were scored using Chandler physical activity intensity cut-points developed for ActiGraph accelerometer placement on the non-dominant wrists of children and adolescents (158). These cut-points have been calibrated for 5-

second epochs. Because ActiLife software only processes activity count data in 60-second epochs, the Chandler cut-points were scaled to match (cut-points designed for 5-second epochs were multiplied by 12). Thus, the scaled vertical axis Chandler cut-points for activity intensity expressed in counts/minute were, (a) Sedentary < 1932, (b) Light = 1932-6348, (c) Moderate = 6349-17532, (d) Vigorous > 17532, and (e) MVPA ≥ 6349 (158). In addition, sedentary bouts were separately defined as a minimum of 10-minute consecutive periods of < 100 counts/minute with no allowance of an interruption (159). Lastly, as part of this step, non-wear times (including sleep periods) were filtered out from scoring. The resulting fully processed activity data were then imported as summary files for data analyses.

Outcome and Exposure variables

Outcome variables: The following physical activity and sedentary behavior outcome variables for 6-17-year-old children and adolescents were examined in the current study: (a) accelerometer-measured average time in MVPA expressed in minutes/day (the total length of time in MVPA in minutes, divided by number of valid wear days) and (b) accelerometer-measured average time in sedentary bouts in minutes/day (the total length of time in sedentary bouts divided by number of valid wear days).

Exposure variables/potential correlates: The following exposure variables for children and adolescents were assessed for their associations with the outcomes: (a) demographics and socio-economic status (e.g., age; gender; race/ethnicity; geography; household income; parent's/caregiver's highest education level), (b) health and anthropometrics (perception of general health status; BMI: age and sex standardized based on CDC-2000 guidelines), (c) neighborhood characteristics (Walk Score: a measure of neighborhood walkability, calculated by and obtained from the Walk Score website (160); perceptions on neighborhood pleasantness for physical activity; perceptions on neighborhood safety from crime; perceptions on neighborhood safety from traffic), (d) parents'/caregivers' health and physical activity (emotional and physical health assessed via SF-12; accelerometer measured average weekly MVPA in minutes; accelerometer measured average daily sedentary bouts in minutes), (e) and screen time in children and adolescents and parents/caregivers (time spent watching TV and videos in hours/day; time spent using computers in hours/day; presence of TV in bedroom: children and adolescents only; usage of phone in bedroom: children and adolescents only). Data on all the exposure variables for children and adolescents were reported by their parents/caregivers with the exception of screentime variables for 12–17-year-old adolescents who self-reported these. A detailed description of the exposure variables is given in Table 1.

Data Analyses

In the present study, analyses were performed on data obtained from all the 6-17-year-old who were surveyed in wave II of SHOW and for whom valid accelerometer wear time data were available. As parents'/caregivers' and children and adolescents' data were in separate datasets, a single dataset was created after matching on a common household identifier. In creating this dataset, exposure variables from a single parent/caregiver were merged with the children and adolescents' data. To prevent bias in selecting the parent/caregiver from a household for merging the datasets, specific decision rules were applied. Firstly, if both parents were available, a parent was randomly chosen. Secondly, if only one parent was available, that parent was selected. In cases where no parents were available, but one grandparent was present, the grandparent was chosen. Similarly, if no parents were available but two grandparents were present, a grandparent was randomly selected. Finally, if neither parents nor grandparents were available, an adult from the same household was randomly chosen. Statistical analyses were performed on the merged dataset as described in the subsequent section.

Means and standard deviations (SD) were used to present descriptive statistics for continuous variables and counts and percentages for categorical variables. To compare the means of minutes/day of MVPA and sedentary bouts across potential categorical predictors, analyses of variance (ANOVA) and t tests were used. Alternatively, Pearson correlations were employed to investigate associations between the continuous predictors and the outcome variables.

Multicollinearity diagnostics were performed on the data, using variance inflation factor for continuous predictors and Cramer's V for categorical predictors. However, no evidence to support the presence of multicollinearity in our data was found. Intraclass coefficients (ICC) were utilized to assess the variance explained by the random effects associated with clustering, specifically due to the siblings sampled from the same households. To compute these coefficients, we fitted a null model to the data, obtaining an ICC of 0.098 for MVPA and 0.151 for sedentary bouts. These coefficients indicated that 9.8% and 15.1% of the variability, respectively, in the outcomes was attributed to household clusters. Given this and the normal distribution of the outcome variable, we decided to use multilevel linear mixed modeling to identify significant predictors associated with accelerometer measured minutes/day of MVPA and sedentary bouts in children and adolescents.

We built two separate mixed models, one for each of the outcomes. Our mixed models included both random effects of households and fixed effects of potential correlates, entered simultaneously. Although we accounted for random effects due to potential non-independence of outcomes in our data, the mixed models did not take into account the three-stage survey design. This is because, it was the adult sampling frame that informed the multistage survey design in

SHOW and the survey design characteristics did not apply to the sample of children and adolescents. Consequently, we also did not use sampling weights.

To prevent overfitting and improving the predictive power of our models, we removed redundant predictors (161). For instance, we dropped variables related to perceptions of neighborhood safety and physical activity pleasantness and instead used Walk Score, an objective variable that captured similar information. Exclusion of these predictors was performed blinded, prior to observing their relationship with the outcomes after running the models. Our decision to drop these variables was based on substantive knowledge, rather than speculation regarding their potential associations with the outcomes (161). Additionally, we combined two exposure variables by combining the duration per day of TV/video watching, and computer use into a single index measuring the duration per day of TV/video/computer use for both children and adolescents and parents/caregivers. We did not use automated stepwise variable selection to exclude regression parameters, as this approach can identify predictors that are unrelated to the outcomes (i.e., noise). Furthermore, it inadequately addresses the problem of overfitting (161).

In order to prevent listwise deletion of observations caused by missing independent variable data and the consequent loss of power in mixed models, we dropped variables with the highest number of missing values. As a result, variables related to accelerometer-measured parent/caregiver MVPA (minutes/week) and sedentary bouts (minutes/day) were removed, as data for these variables were missing for 64 observations. We also ran models without dropping these variables. In these models, only about two-thirds of the observations were used due to missing data. However, the estimates for the independent variables did not change significantly. The next variables with the highest amount of missing data were SF-12-measured parent/caregiver health variables, with 41 missing values. However, we retained these variables in the models and the final mixed models were run on 252 observations, for which complete data on all independent variables were present. Our final models included 26 regression parameters. Given our analytic sample size of 252, this falls on the lower end of the recommended range of 10-20 observations per parameter (162).

We report unstandardized regression coefficients (β) accompanied by 95% Confidence Intervals (CIs) for all the estimates. A probability level of 0.05 was used for all statistical tests. All analyses were performed in SAS 9.4 (SAS, Cary, North Carolina).

Results

This study included data from children and adolescents aged 6 to 17 years (n = 308) sampled in wave-II of SHOW and met the valid accelerometer wear time requirements. These participants were from a total of 197 distinct households, with 40% households consisting of siblings who were surveyed together. Parent/caregiver reported data were obtained from parents (n = 262), grandparents (n = 13), and others (aunt, uncle, older sibling etc.) (n = 33).

The sociodemographic, anthropometric, health, neighborhood, and screen time characteristics of children and adolescents and health, physical activity, and screen time characteristics of parents/caregivers are described in Table 1. The mean age of the sample was 10.9±3.4 years and 51% were boys. The sample was predominantly non-Hispanic white (57.8%) and 30% lived in rural areas. On average, children and adolescents spent 43±28 minutes/day in MVPA and 103±58 minutes/day in sedentary bouts (See Table 2).

Exploratory Pearson correlational analysis for continuous predictors demonstrated significant positive associations between participants' BMI and Walk Score and the duration of sedentary bouts, as shown in Table 3. Additionally, results from ANOVA and t tests indicated that the means of minutes/day of MVPA differed significantly across categories of 'perceptions on neighborhood pleasantness for physical activity' ($p = 0.02$), while the means of minutes/day of sedentary bouts differed significantly across categories of 'perceptions on neighborhood safety from crime' ($p = 0.01$). However, the means of minutes/day of MVPA or sedentary bouts did not differ significantly across categories of any other exposure variable (See Table 4).

Table 5 displays the multivariate associations between potential correlates and accelerometer-measured minutes/day of MVPA and sedentary bouts in children and adolescents. The mixed models included 12 exposure variables and 26 regression parameters. The results indicated a non-significant but meaningful[4] inverse relationship between children and adolescents' screen time (measured by hours/day of TV/video/computer use) and MVPA. Specifically, children and adolescents who spent ≥ 5 hours/day in screen time engaged in approximately 12 fewer minutes of MVPA/day compared to those who engaged in ≤ 2 hours/day of screen time ($p = 0.06$). The estimates for sedentary bouts also exhibited a similar non-significant trend in relation to children and adolescents' screen time. Specifically, those who engaged in ≥ 5 hours/day of screen time had nearly a 20-minute increase in sedentary bouts/day relative to those who engaged in ≤ 2 hours/day ($p = 0.18$).

Another correlate that showed a non-significant yet meaningful relationship with MVPA was the Walk Score. As the Walk Score increased, the minutes/day of MVPA decreased ($\beta = -0.17$, $p = 0.09$). A similar non-significant association was also observed for sedentary bouts, with the duration of sedentary bouts/day increasing with an increase in Walk Score ($\beta = 0.29$, $p = 0.18$).

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[4] In the context of regression estimates, the term "meaningful" describes associations or relationships that possess practical significance or substantive importance, irrespective of their statistical significance. While statistical significance aids in determining whether an observed relationship is likely due to chance, meaningfulness extends beyond statistical tests to encompass the practical implications and relevance of the estimated associations. Even non-significant regression estimates can be meaningful if they align with theory, offer logical explanations, or provide valuable insights into the research question.

The results further indicated that the BMI of children and adolescents was a significant correlate, with the minutes/day of sedentary bouts increasing as BMI increased ($\beta = 0.26$, $p = 0.04$). Moreover, there were meaningful but non-significant associations between sedentary bouts and gender. Specifically, the duration of sedentary bouts (minutes/day) was lower for boys ($\beta = -11.25$, $p = 0.16$) compared to girls.

Discussion

To address the gaps in evidence regarding the factors that affect physical activity and sedentary behavior in children and adolescents, this study investigated a range of potential correlates that have been previously assessed, as well as factors that are under-researched. Specifically, potential correlates in the categories of sociodemographic, anthropometric, neighborhood, screen-time, and parental health were assessed for their associations with accelerometer-measured MVPA and sedentary bouts in a sample of 308 children and adolescents surveyed as part of wave II of SHOW. The results of the multivariate analyses revealed meaningful differences in MVPA and sedentary bouts in relation to several factors including BMI, gender, Walk Score, and screen time.

One of the modifiable correlates that emerged from the present analyses was the duration of time that children and adolescents spent engaged in screen-time activities, such as watching TV, using smartphones, and using computers. In our study, a longer duration in these screen-based activities was associated with poorer MVPA and sedentary bout outcomes. While many studies support our finding (163–166), emerging evidence suggests that the impact of screen time on physical activity may vary depending on the nature of the screen-based activities (167–169). For instance, exergaming, a type of screen time activity, has been shown to promote physical activity in children and adolescents (168). Despite the inconsistent evidence, it is important to address screen time as part of health promotion interventions in this population as its consumption has increased significantly in the recent years and particularly since the COVID-19 pandemic (170). The ownership and access to digital devices among youth have also seen a substantial surge (171). However, it is also important to recognize the nuanced nature of screen time when designing such interventions, as it can present multifaceted opportunities for education, recreation, socialization, and even physical activity promotion among the young (168,172–174). Future research should prioritize disentangling the nature and characterization of screen time in children and adolescents. By understanding the specific aspects of screen time and their impact on physical activity, interventions can be tailored to effectively promote activity while recognizing the benefits and potential positive aspects of certain screen-based activities.

Another important finding of the present study was an inverse association between Walk Score and both MVPA and sedentary bouts. While this finding contradicts results obtained from studies in adults (175,176), it is in line with studies among children and adolescents (177,178) that report null or inverse associations. These studies suggest that Walk Score is primarily designed to assess walkability in urban areas, considering factors such as the presence of shops, public transportation, parks, movie theaters, libraries, and places of worship in the calculation. However, rural and suburban areas, which may also be walkable, can receive lower scores due to the absence of these specific urban environmental characteristics (175,177). As more than 50% of the children in our study were from suburban and rural areas, it is possible that Walk Score did not adequately reflect the walkability in our study population. Moreover, these environmental characteristics have little relevance to children and adolescents' overall physical activity, and essential features that can facilitate greater active play, such as dead-end streets and open spaces, are not included in the Walk Score (178). As a result, Walk Score may not be an accurate measurement of an area's walkability for children and adolescents unless it is adjusted to account for urban environmental characteristics (177) and "playability" (178).

Another factor that may explain the relationship between Walk Score and physical activity outcomes in our study is that walking plays a relatively minor role in children and adolescents' overall physical activity levels (177). The young population tends to accumulate physical activity at various locations, including schools, after-school centers, outdoor and indoor recreational spaces, and homes, which may be independent of neighborhood walkability (105). Therefore, a higher Walk Score may not necessarily lead to a positive change in the physical activity and sedentary behavior outcomes of children and adolescents. There is a need to validate and develop a metric that incorporates built environment features supporting children and adolescents' activity, such as broad sidewalks, dead-end streets, playgrounds, parks, and open spaces for play. The utilization of such an index in future research would contribute to a deeper understanding of how the neighborhood environment influences physical activity levels in this population.

Our findings are also consistent with existing evidence indicating a gender-based disparity in sedentary behavior, with girls generally being more sedentary than boys, as observed in studies utilizing questionnaires (48) and objective measures (39,179). Additionally, our study revealed a positive association between higher BMI and increased time spent in sedentary bouts among children and adolescents. This aligns with longitudinal studies that have demonstrated a predictive relationship, with obesity being a risk factor for increased sedentary time in this population (180,181). However, given the cross-sectional nature of our study, it is important to acknowledge that this association may also reflect a bidirectional relationship between the two variables. These identified disparities based on demographics and anthropometrics emphasize the importance of targeted health promotion interventions addressing these specific subgroups.

Strengths and Limitations

The key strength of this study includes the use of accelerometer-measured outcomes. Using direct measures allowed us to overcome two major challenges associated with self/proxy reported data; over- or under-reporting of behaviors and misclassification of activity intensity (51). Direct assessment provided a more accurate and reliable assessment of physical activity and sedentary behavior, allowing for a better understanding of the factors that influence these behaviors in children and adolescents. Furthermore, the accelerometer was placed on the wrist, which has been associated with better wear compliance in the youth compared to hip placement (182,183). Another strength of our study was the comprehensive examination of interrelated social determinants that shape physical activity and sedentary behavior, encompassing demographic, socioeconomic, parental, and neighborhood influences. By considering these factors together, we gained valuable insights into the upstream challenges and conditions that shape the young population's lives and play a crucial role in their health outcomes (184). Finally, the large sample size is also a strength of the current study. It enabled a comprehensive examination of multiple potential correlates simultaneously.

Nonetheless, there are limitations to consider when interpreting our findings. Although we performed a comprehensive evaluation of potential correlates across several domains, we could not assess important psychosocial factors that are known to predict physical activity and sedentary behavior in children and adolescents, such as self-efficacy, intention to be active, and perceived barriers, due to data limitations in SHOW (185). Future research should aim to include these factors in conjunction with the current set of potential correlates to conduct a more thorough investigation. Additionally, the cross-sectional design of SHOW prevented us from establishing causal relationships. To gain a deeper understanding of the predictors of physical activity and sedentary behavior in this population, future studies should employ longitudinal design. These studies would provide valuable insights into the temporal relationships and potential causal pathways between variables (186). Another limitation arises from the use of a non-validated questionnaire to assess screen time in both children and adults. The questionnaire was based on the NHANES screen time survey, but it has not undergone validity or reliability testing (187). Consequently, the accuracy of responses regarding the duration of TV/video and computer usage may be compromised. The questionnaire collected responses in 1-hour increments, requiring respondents to select the closest response category to their actual usage. This may have led to rounding errors, resulting in either underestimation or overestimation of screen time (187).

Moreover, accelerometers, while having many advantages in physical activity research, are not without their limitations. They may underestimate certain activities, such as bicycling, and cannot be worn during water-based activities (188). Additionally, there is a lack of consensus among researchers on the specifications of accelerometer data processing and intensity cut points, which may lead to unreliable results (189). Furthermore, as epoch length has a significant impact on activity counts, it is essential to use the same epoch length as the calibration study (190). However, due to the absence of calibration studies for wrist-worn ActiGraph accelerometers in children and adolescents for 1-second epochs, we had to rely on the Chandler intensity cut-points calibrated for 5-second epochs. Furthermore, aside from the general limitations associated with accelerometers, research has indicated that among children, placing the device on the wrist is linked to inadequate discrimination of MVPA compared to placing it on the waist or ankle (191). Additionally, the stationary position of the wrist during bicycling can lead to misclassification of activity levels (192).

In addition, while we took great care in our mixed models to prevent overfitting by carefully excluding redundant predictors and combining predictors, this approach was not without limitations and likely resulted in data loss (161). To address overfitting in linear models, shrinkage and penalization techniques such as LASSO, LAR, and ridge regression are recommended (161). Additionally, combining predictors using principal component analysis or factor analysis is a better approach (161). However, these approaches may not allow for the adjustment of random effects. Lastly, in our sample, we had large missing data for a few variables, which due to list wise deletion in mixed models, contributed to a loss of power and exclusion of important variables (e.g., parent/caregiver MVPA and sedentary bouts).

Conclusion

The current study contributed to expanding the evidence base on the correlates of children and adolescents' accelerometer measured physical activity and sedentary behavior by undertaking a comprehensive evaluation. Meaningful associations were observed for several variables, including screen-time, Walk Score, BMI, and gender. These findings not only provide valuable insights to inform the design of future interventions related to physical activity and sedentary behavior in the young population, but also highlight subgroups that may be in need of such interventions.

Table 1: Descriptive statistics for potential correlates of physical activity and sedentary behavior of children and adolescents (n = 308)

Continuous correlates	**Mean**	**SD**	**Description**
Age	10.9	3.4	Parent/caregiver reported age in years at the time of consent.
BMI percentile	64.1	29.8	Direct measurement of weight and height by research team (BMI percentile is age and sex standardized based on CDC 2000 guidelines).
Walk Score	24.8	23.6	Walk Score was calculated by and obtained from the Walk Score website (http://www.walkscore.com) based on respondent addresses. For each address, Walk Score analyzes hundreds of walking routes to nearby amenities. Points are awarded based on the distance to the amenities. A higher Walk Score suggests higher walkability. Scores range from 0-100.
Parent/caregiver's SF-12 mental health score	49.7	9.5	Parent/caregiver reported norm-based SF-12 mental health component summary measure.
Parent/caregiver's SF-12 physical health score	51.9	8.6	Parent/caregiver reported norm-based SF-12 physical health component summary measure.
Parent/caregiver's average time in sedentary bouts (minutes/day)	198	165	Accelerometer measured weekly average of MVPA of the parent/caregiver*.
Parent/caregiver's average MVPA (minutes/week)	183	105	Accelerometer measured daily average of sedentary bouts of the parent/caregiver*.
Categorical correlates	**N**	**Percent**	**Description**
Sex			Parent/caregiver reported biological sex.
Male	157	51	
Female	151	49	
Geography (RUCA)			The rural-urban commuting area (RUCA) codes classify U.S. census tracts using measures of population density, urbanization, and daily commuting.
Urban	142	46	
Suburban	75	24	
Rural	91	30	
Race and ethnicity			Combination of parent/caregiver reported race and ethnicity in 4 categories.
Non-Hispanic white	178	58	
Non-Hispanic African American	33	11	
Hispanic	5	2	
Other	16	5	

Missing	76	25	
General health			Parent/caregiver reported, “In general, how would you describe the minor’s health?”
Excellent	97	32	
Very good	96	31	
Good	32	10	
Fair	2	1	
Annual household income			Parent/caregiver reported combined household income over last 12 months before taxes.
≤ $49,999	94	33	
$50000-$99,999	91	32	
≥ $100,000	101	35	
Parent/caregiver's highest education			Parent/caregiver reported highest level of school completed or highest degree received by self.
Highschool or lower	58	20	
Associate degree: vocational/academic	98	33	
Bachelor's degree	92	31	
Master's degree or higher	45	15	
Community physically active			Parent/caregiver reported, “How would you rate your community as a place to be physically active?”
Not pleasant	32	10	
Somewhat pleasant	124	40	
Very pleasant	125	41	
Community safe from crime			Parent/caregiver reported, “How safe from crime is your community for walking or riding a bike?”
Not safe	11	4	
Somewhat safe	92	30	
Very safe	177	58	
Community safe from traffic			Parent/caregiver reported, “How safe from traffic is your community for walking or riding a bike?”
Not safe	37	12	
Somewhat safe	147	48	
Very safe	96	31	
Duration of TV and video watching/day			Parent/caregiver reported for ages 6-11 years. Self-reported for ages 12-17 years.
< 1 hour	60	19	
1-2 hours	162	53	

≥ 3 hours	86	28	“Over the past 30 days, on average how many hours per day did you sit and watch TV or videos?”
Duration of computer use/day			Parent/caregiver reported for ages 6-11 years. Self-reported for ages 12-17 years. “Over the past 30 days, on average how many hours per day did you use a computer or play computer games outside of school? Include PlayStation, Nintendo DS, games on a smart phone or tablet, or other portable video games.”
< 1 hour	90	29	
1-2 hours	139	45	
≥ 3 hours	78	25	
TV in bedroom			Parent/caregiver reported for ages 6-11 years. Self-reported for ages 12-17 years. “Do you have a TV in your bedroom?”
Yes	103	33	
No	205	67	
Use of smartphone/tablet in bedroom			Parent/caregiver reported for ages 6-11 years. Self-reported for ages 12-17 years. “Do you use a smartphone, laptop, or tablet for entertainment in your bedroom?”
Yes	191	62	
No	117	38	
Duration of TV and video watching/day			Parent/caregiver reported time spent per day watching TV and videos.
< 1 hour	68	22	
1-2 hours	152	49	
≥ 3 hours	83	27	
Duration of computer use/day			Parent/caregiver reported time spent per day using computer.
< 1 hour	140	45	
1-2 hours	129	42	
≥ 3 hours	33	11	

* **Accelerometer considerations for adults in SHOW:** Placement of the accelerometer for the adults was at the hip. Wear time validation was performed via Troiano (2007) parameters and Freedson Adult (1998) count cut points were used for physical activity intensity classification.

Table 2: Means and SDs of physical activity and sedentary behavior outcome variables

Outcome variables	Mean	SD
Time in MVPA (minutes/day)	43	28
Time in Sedentary bouts (minutes/day)	103	58
Time in light physical activity (minutes/day)	275	72
Steps/day	12642	2766

Table 3: Results of exploratory bivariate analyses for potential correlates using Pearson Correlation

	MVPA (minutes/day)	Sedentary bouts (minutes/day)
	Correlation coefficient (95% CI)	Correlation coefficient (95% CI)
Age	0.02 (-0.10, 0.13)	-0.07 (-0.18, 0.05)
BMI percentile	-0.04 (-0.15, 0.07)	0.13* (0.02, 0.24)
Walk Score	-0.03 (-0.15, 0.08)	0.12* (0.01, 0.23)
Parent/caregiver's SF-12 mental health score	-0.04 (-0.16, 0.09)	0.03 (-0.09, 0.15)
Parent/caregiver's SF-12 physical health score	-0.04 (-0.16, 0.08)	-0.07 (-0.19, 0.05)
Parent/Caregiver's average time in sedentary bouts (minutes/day)	-0.03 (-0.16, 0.09)	-0.11 (-0.23, 0.02)
Parent/Caregiver's average MVPA (minutes/week)	-0.03 (-0.16, 0.10)	-0.04 (-0.16, 0.09)

*Significant at $p = 0.05$

Table 4: Results of exploratory bivariate analyses for potential correlates using one way ANOVA and t tests.

Potential correlates	MVPA (minutes/day)				Sedentary bouts (minutes/day)			
	Mean	95% CI of mean		p value	Mean	95% CI of mean		p value
Demographics, socioeconomic factors, and health								
Sex								
Male	41.8	37.5	46.1	0.68	101.2	92.8	109.7	0.51
Female	43.7	39.2	48.3		105.6	95.6	115.6	
Geography (RUCA)								
Urban	41.4	36.7	46.0	0.70	105.4	95.9	114.9	0.64
Suburban	43.7	37.3	50.1		97.9	85.3	110.5	
Rural	44.2	38.6	49.9		104.7	91.9	117.4	
Race and ethnicity								
Non-Hispanic white	42.9	38.6	47.1	0.25	99.9	91.5	108.3	0.31
Non-Hispanic African American	42.5	34.1	51.0		108.7	87.3	130.1	
Hispanic	46.7	4.2	89.2		122.4	65.3	179.6	
Other	28.7	19.7	37.7		80.6	58.9	102.3	
General health								
Excellent	41.7	36.0	47.3	0.83	94.5	84.0	105.0	0.30
Very good	42.2	36.6	47.9		103.0	90.9	115.2	
Fair or Good	44.9	35.3	54.6		110.5	91.0	129.9	
Annual household income								
≤ $49,999	43.5	38.1	49.0	0.75	105.5	94.6	116.5	0.85
$50000-$99,999	41.8	35.3	48.2		104.2	91.6	116.8	
≥ $100,000	40.6	35.4	45.7		101.0	89.0	113.0	
Parent/caregiver's highest education								
Highschool or lower	44.0	36.5	51.4	0.58	98.6	85.7	111.6	0.29
Associate degree: vocational/academic	45.4	39.5	51.3		110.1	97.8	122.5	
Bachelor's degree	41.7	36.0	47.3		96.3	85.2	107.3	
Master's degree or higher	38.8	30.7	46.9		110.4	89.8	131.0	

Neighborhood								
Community physically active								
Not pleasant	41.0	32.3	49.8	**0.02**	108.6	88.4	128.8	0.42
Somewhat pleasant	47.0	42.0	52.0		105.8	95.2	116.4	
Very pleasant	37.6	32.9	42.4		97.4	87.4	107.4	
Community safe from crime								
Not safe	40.4	21.4	59.5	0.57	83.9	54.9	112.9	**0.01**
Somewhat safe	44.8	38.9	50.6		116.5	103.3	129.6	
Very safe	41.1	37.2	45.1		96.2	88.1	104.3	
Community safe from traffic								
Not safe	42.6	34.0	51.3	0.74	116.7	94.5	138.8	0.25
Somewhat safe	43.4	38.8	47.9		101.4	92.0	110.7	
Very safe	40.6	35.0	46.1		98.4	87.2	109.6	
Screen time								
Duration of TV and video watching/day								
< 1 hour	41.4	34.3	48.5	0.91	96.7	83.7	109.6	0.38
1-2 hours	43.0	38.5	47.4		102.4	92.8	111.9	
≥ 3 hours	43.4	37.7	49.1		110.0	98.1	121.8	
Duration of computer use/day								
< 1 hour	47.1	41.0	53.2	0.19	102.5	90.1	114.8	0.97
1-2 hours	41.5	36.8	46.2		103.3	93.5	113.0	
≥ 3 hours	39.9	34.1	45.6		104.6	91.6	117.6	
TV in bedroom								
Yes	43.1	37.8	48.4	0.89	101.2	90.6	111.8	0.63
No	42.6	38.7	46.5		104.5	96.2	112.7	
Use of smartphone/tablet in bedroom								
Yes	42.9	38.7	47.0	0.94	101.9	93.7	110.1	0.56
No	42.6	37.9	47.4		105.8	95.1	116.5	
Parent's/caregiver's screen time								
Duration of TV and video watching/day								

< 1 hour	42.2	35.6	48.8	0.89	95.8	81.5	110.1	0.28
1-2 hours	42.1	37.3	47.0		102.6	93.9	111.2	
≥ 3 hours	43.9	38.8	49.0		110.7	97.3	124.2	
Duration of computer use/day								
< 1 hour	41.1	36.7	45.4	0.14	104.0	94.6	113.4	0.57
1-2 hours	45.8	40.6	51.0		105.0	94.4	115.6	
≥ 3 hours	36.2	26.5	45.8		93.4	76.5	110.3	

Note: *p* values are from t tests for exposure variables with two levels and one way ANOVA for exposure variables with more than 2 levels.

Table 5: Results from multilevel linear mixed models for associations of potential correlates with MVPA and Sedentary bouts.

Potential correlates	**MVPA (minutes/day)**				**Sedentary bouts (minutes/day)**			
	β	**95% CI**		**p value**	**β**	**95% CI**		**p value**
Demographics, socioeconomic factors, and health								
Age	0.1	-0.9	1.2	0.81	-1.2	-3.5	1.1	0.31
Sex								
Female	-	-	-	-	-	-	-	-
Male	-1.0	-7.9	6.0	0.78	-11.3	-26.8	4.3	0.16
Geography (RUCA)								
Rural	-	-	-	-	-	-	-	-
Urban	-2.9	-12.8	7.1	0.57	0.9	-20.7	22.5	0.93
Suburban	-1.1	-11.1	8.9	0.82	-4.9	-26.5	16.8	0.66
Race and ethnicity								
Non-Hispanic white	-	-	-	-	-	-	-	-
Non-Hispanic African American	4.4	-9.1	17.8	0.52	-3.5	-32.7	25.7	0.81
Hispanic	-2.4	-31.1	26.4	0.87	4.8	-58.0	67.6	0.88
Other	-12.3	-28.3	3.7	0.13	-20.1	-55.5	15.3	0.26
Missing	2.7	-10.5	15.9	0.69	9.0	-20.2	38.2	0.55
Annual household income								

≤ $49,999	-	-	-	-	-	-	-	-
$50000-$99,999	-6.1	-15.4	3.1	0.19	3.1	-17.2	23.4	0.76
≥ $100,000	-6.5	-16.3	3.4	0.20	3.2	-18.3	24.6	0.77
General health								
Very good or excellent	-	-	-	-	-	-	-	-
Fair or good	2.0	-9.4	13.4	0.73	6.9	-18.5	32.3	0.59
BMI percentile	0.0	-0.2	0.1	0.48	0.3	0.0	0.5	**0.04**
Neighborhood								
Walk Score	-0.2	-0.4	0.0	**0.09**	0.3	-0.1	0.7	0.18
Screen time								
Duration of TV/video/computer use/day								
≤ 2hours	-	-	-	-	-	-	-	-
3-4 hours	-9.2	-21.2	2.8	0.13	16.7	-9.9	43.2	0.22
≥ 5 hours	-12.5	-25.6	0.6	**0.06**	19.6	-9.4	48.5	0.18
Parent's/caregiver's health								
SF-12 mental health score	0.0	-0.4	0.4	0.84	0.2	-0.7	1.1	0.68
SF-12 physical health score	-0.2	-0.6	0.3	0.44	-0.2	-1.2	0.7	0.63
Parent/caregiver's screen time								
Duration of TV/video/computer use/day								
≤ 2hours	-	-	-	-	-	-	-	-
3-4 hours	0.4	-10.3	11.0	0.94	-1.9	-24.9	21.2	0.87
≥ 5 hours	-4.3	-17.3	8.8	0.52	-1.2	-29.6	27.2	0.93

Note: β = β-coefficient. Estimates and *p* values are from Multilevel linear mixed models with household as a random factor (n = 252)

Chapter 5 - Discussion of results and recommendations

The aims of this dissertation were to contribute to the understanding of factors influencing physical activity in children and explore accessible and scalable interventions to enhance activity levels and psychosocial health. To achieve these goals, two studies were conducted, forming the basis of three manuscripts included in this dissertation. The first study, known as ACTIWEB-PA, employed a pilot randomized controlled design to investigate the feasibility and effectiveness of a novel, youth-targeted, 12-week web-based movement integration program delivered remotely, in a home setting. This study examined the feasibility outcomes, such as recruitment, retention, intervention adherence and satisfaction, as well as the intervention effects on physical activity and psychosocial health in insufficiently active children from the mid-western United States. The second study utilized data from wave-II of Survey of Health of Wisconsin (SHOW) (59) to explore a range of factors, such as sociodemographic and anthropometric characteristics, neighborhood factors, screen-time behaviors, and parental influences, that may affect accelerometer measured physical activity and sedentary behavior of children and adolescents.

The findings of the first study, the ACTIWEB-PA pilot trial, demonstrated the feasibility of conducting the research, as evidenced by the successful recruitment, retention, and intervention adherence outcomes. In addition, the movement integration intervention, administered via the UNICEF Kid Power web platform (107), was highly regarded by the participating families, who found it acceptable, pragmatic, appropriate, and enjoyable. Nevertheless, a decline in program engagement was reported during the latter phase of the intervention. Findings from this study also included suggestions provided by the participating families to enhance the appeal of the intervention, along with insights on strategies that they used to adhere to the intervention.

Despite the high feasibility and satisfaction observed in the ACTIWEB-PA study, the movement integration intervention did not yield significant improvements in physical activity outcomes. Additionally, no significant effects were observed on HRQoL and most aspects of Self-Concept. However, the overall high feasibility and acceptability of the study suggests that future full-scale eHealth exercise interventions delivered remotely in home settings have the potential to impact children's physical activity levels. Further research is needed to better understand the factors influencing intervention effectiveness and to develop strategies to optimize the impact of such interventions.

Results from the second study, analyzing data for children and adolescents from Survey of Health of Wisconsin, revealed variations in accelerometer measured MVPA and sedentary bouts in relation to several correlates. Specifically, non-significant yet meaningful associations were observed between MVPA and screen time, as well as MVPA and Walk Score (160). Additionally, a significant association was found between sedentary bouts and BMI, while a non-significant yet meaningful association was observed between sedentary bouts and gender. These findings provide valuable insights into the relationship between accelerometer measured MVPA and sedentary bouts with various correlates in children and adolescents, highlighting the factors and population sub-groups that need to be considered when designing physical activity interventions.

Together, these findings represent a significant contribution to the field of children's physical activity epidemiology, offering valuable insights that can inform the development and implementation of future interventions aimed at promoting physical activity and reducing sedentary behavior in the young population. In the subsequent sections, I have provided a summary of the key findings, highlighted the lessons learned, and provided recommendations for future research.

ACTIWEB-PA study

Feasibility of the study

The ACTIWEB-PA study surpassed the *a priori* recruitment and retention rates. It also demonstrated a minimal attrition rate and higher intervention adherence compared to a similar youth targeted web-based exercise intervention (78). The favorable outcomes observed in our study can be attributed to the convenience offered by entirely remote procedures. All study procedures, including consent and assent, instructional calls, and assessments (surveys, accelerometry, and interviews), were conducted remotely using digital platforms.

In the field of physical activity intervention research, remotely delivered interventions are widely available (30,35), but studies using entirely remote procedures are limited (193–195). Adopting entirely remote procedures or an "unmoderated research approach," as coined in developmental science, offers numerous potential benefits (196). This approach enhances feasibility by providing cost-effectiveness, efficiency, replicability, and the ability to reach traditionally hard-to-reach participant populations (196,197). By eliminating the need for in-person visits, remote procedures overcome logistical barriers and facilitate greater participation (197). This approach is particularly relevant for research involving children who typically have limited independent mobility and busy schedules due to school, extracurricular activities, and sports participation (198). Such constraints may make it challenging for them to participate in in-person studies. In our study, the remote approach not only provided convenience and improved participant retention, but also facilitated efficient recruitment within a concise three-month period by eliminating scheduling challenges associated with in-person meetings. Furthermore, the remote approach enabled us to recruit a relatively geographically diverse sample from various cities in Wisconsin (for example, Waukesha, Milton, Platteville, New Berlin, and others). This geographical diversity would not have been feasible using a traditional moderated approach requiring families to visit the research center at the University of Wisconsin in Madison. As one of the few studies in the field of children's physical activity epidemiology that employed an entirely remote approach, our study has the potential to serve as a valuable guide for future research in this area.

In addition to the remote approach that facilitated feasibility in our study, proactive measures were implemented to optimize adherence to the intervention, including the implementation of weekly reminder emails sent to parents. These reminders not only played a key role in promoting participant engagement but also helped make families more knowledgeable on the benefits of physical activity (See appendix for an example weekly reminder email). Additionally, we placed a strong emphasis on promoting children's enjoyment in our intervention. We recognized that sustained adherence is facilitated by enhancing intrinsic motivation through increased enjoyment (70,82,83). To achieve this, we prioritized autonomy for the children, allowing them to have control over various aspects of their exercise experience, such as selecting specific exercises, choosing the location and timing, and deciding on exercise partners (70). While we provided clear instructions on exercise volume, frequency, and duration, we empowered the children to tailor their exercise sessions based on their personal preferences. This autonomy proved to be instrumental in fostering enjoyment and motivation, leading to higher adherence to the exercise program.

Based on our study findings, future web-based physical activity interventions should focus on improving adherence by implementing proactive measures such as reminders and prioritizing enjoyability and autonomy for children. Additionally, utilizing remote approaches can enhance the feasibility of conducting such studies.

Intervention acceptability and satisfaction

Participant and parent feedback from the end-of-study interviews revealed high levels of satisfaction with the movement integration program. Key factors contributing to this positive response included age-appropriateness of the videos, engaging and entertaining content, freedom of choice in selecting exercise videos, opportunities for family involvement, a philanthropic incentive system promoting social justice, and a manageable time commitment of 20 minutes per day. These findings highlight the significance of incorporating these elements in future movement integration programs to enhance participant satisfaction and engagement.

An important factor contributing to participant satisfaction with the program was the opportunity to engage in exercises with family and friends. This finding aligns with previous research on family-based programs, which have shown high levels of program satisfaction (199,200). Furthermore, family participation has been found to significantly moderate the effectiveness of physical activity interventions in children (201,202). While ACTIWEB-PA was not a family-based program in the traditional sense as we did not explicitly focus on co-activity or measured it, we did emphasize parental support of children's exercise. This involved ensuring space and device availability during exercise sessions and encouraging parents to join their child in participating, thereby promoting adherence to the program. Based on the positive impact of family participation observed in our study, we recommend exploring the development of a family-based movement integration program. This approach can further enhance adherence, enjoyment, and contribute to the overall health of the whole family.

While participants reported overall high adherence, a gradual decline in interest and uptake was observed in the latter phase of the intervention as has been observed in a previous web-based, youth targeted study (90). This decline in intervention adherence in our study was reportedly due to two reasons. Firstly, the novelty of the exercise videos included in the intervention diminished over time (92,93). Participants noted that while there was a wide selection of videos available at the beginning of the intervention, the addition of new videos to the website became sporadic and limited. Consequently, in the latter phase of the intervention, the available video selection did not adequately cater to the interests of the children, who expressed a desire for greater variety including activities beyond dance, such as sports skills.

The second reason, as reported by participants and parents was the increased engagement in outdoor activities as spring arrived (99). The study recruitment and intervention period spanned a six-month period from January to June 2022, encompassing the transition from winter to spring. In the midwestern United States, where the study was conducted, the winter weather is often severe, limiting outdoor play opportunities for children (203). As a result, with the arrival of warmer weather in spring, children had the chance to utilize outdoor spaces for play after an extended period of restricted access. Families in our study reported that while the exercise videos provided valuable alternatives during the winter months when outdoor options were limited, they were less utilized in the spring as families preferred hiking, biking, free play, and participating in organized sports (94–97).

Despite the decline in adherence to exercise videos during the latter phase, it is important to view this as a positive outcome rather than a failure. Families engaged in alternate forms of outdoor physical activity at the same time as adherence to exercise videos was declining. This is noteworthy because the children in our study had low levels of physical activity at baseline, and their participation in any form of physical activity, whether through exercise videos or outdoor activities, is a promising finding. The goal of this research was not to increase physical activity using exercise videos alone, but rather to enhance the overall physical activity levels of children. The translational nature of the intervention, acting as a catalyst for promoting conversations on physical activity and creating a culture of physical activity within households, must be acknowledged, and valued.

In summary, based on feedback from participants and parents, we recommend incorporating novel elements and diverse video types when designing future interventions to sustain children's interest. This will help to ensure that the exercise videos remain engaging and enjoyable over time. Additionally, it is important to recognize the value of exercise videos in increasing activity levels during periods when children have limited access to outdoor play due to inclement weather. eHealth physical activity interventions can be particularly beneficial during these periods, providing opportunities for insufficiently active children to stay active at home and avoid sedentary behavior.

Intervention effects

Adjusting for baseline imbalances in the outcomes, results demonstrated that the movement integration intervention was ineffective in improving the physical activity outcomes of the children. It is important to note though that due to the pilot nature of the study, these results should be interpreted as only indicative. Despite the null effects, the insights gained from this study provide a foundation for future research in this area. Further research and larger-scale trials are warranted to explore the potential effectiveness of such interventions in promoting physical activity among children.

Based on the findings from our study, we offer insights for future program improvements to impact the physical activity levels in children. Increasing the daily exercise duration to 60 minutes, in line with federal guidelines for children, may optimize the intervention's impact on physical activity outcomes (60). While the short daily duration of 20 minutes/day of MVPA was chosen to prioritize adherence, future studies could gradually increase the exercise dose over the course of the program to achieve the recommended duration of 60 minutes/day of MVPA. Additionally, it is important to ensure that participants are performing the exercises at the intended moderate to vigorous intensity. Regular check-ins with parents and participants can emphasize the importance of maintaining moderate to vigorous intensity during exercise sessions (129). Furthermore, implementing more robust measures of implementation fidelity is recommended to monitor the intensity of exercise performance. Currently, there is a lack of validated frameworks for assessing intervention fidelity in remote, web-based intervention research. However, drawing inspiration from established frameworks used in public health intervention research, possible approaches for measuring fidelity in web-based interventions could include the use of daily diaries or having participants wear accelerometers specifically during exercise periods for a few weeks during the intervention period (204,205).

Additionally, for future evaluations, we recommend implementing a movement integration program that utilizes a web platform incorporating behavior change techniques such as social comparison, goal setting, self-monitoring, and performance feedback from the outset (131). It is important to note however, that in our intervention, while the web-delivery platform did not incorporate behavioral change techniques, the exercise prescription was based on the

SAAFE principles rooted in the self-determination theory (70,81). By combining the theory informed exercise prescription with a web delivery platform backed by behavior change strategies, we can facilitate greater support, motivation, and possibly long-term improvements in overall physical activity of the children (131). In summary, future interventions can enhance their impact by increasing exercise duration, implementing intensity monitoring, and utilizing a web platform with behavior change strategies.

Our intervention also did not lead to significant changes in most of the psychosocial health variables. This may be attributed to the lack of changes in physical activity levels, which were expected to be the primary mechanisms for influencing the secondary outcomes. This observation aligns with other physical activity intervention studies in children, suggesting that improvements in physical activity are necessary for driving changes in secondary outcomes (137,139). Other alternative explanations for the lack of significant changes in the secondary outcomes include a potential ceiling effect, as the baseline levels of psychosocial health were already high in our sample of healthy children (206,207). Additionally, there might have been a lag effect, where changes in psychosocial health take time to manifest following sustained changes in physical activity behavior (137). Lastly, the daily volume of physical activity in our intervention (20 minutes) may have been insufficient to elicit significant changes in psychosocial health (6). To improve psychosocial health outcomes, future interventions should consider extending the intervention duration and increasing the daily exercise volume to meet the recommended guideline of 60 minutes of moderate-to-vigorous physical activity per day (6,60). By implementing these adjustments, future interventions can better promote positive psychosocial health in children.

SHOW study

The analyses of the 308 children and adolescents who met the criteria for valid accelerometer wear time in wave II of SHOW revealed several factors that influenced their objectively measured MVPA and sedentary behavior. Notably, we found non-significant yet meaningful associations with screen time duration, walk score, BMI, and biological sex. These findings have important implications for future interventions, as they provide guidance on factors and population subgroups that need to be targeted.

Based on our results, future physical activity interventions should target specific population groups such as girls and young individuals who are overweight or obese. Additionally, based on our results, screen time reduction interventions may promote physical activity. However, it is important to consider that screens have become an integral part of children and adolescents' lives in today's digital age, and arbitrary reduction strategies may not be effective (171). A deeper understanding of the nature of screen time for youth is needed, and interventions should focus on screen activities that are voluntary and do not offer enrichment, education, or activity opportunities (168,172–174). Thus, a pilot trial to optimize screen time reduction intervention in children and adolescents is first necessary before conducting a full-scale intervention. A pilot trial would help refine strategies and approaches to effectively reduce screen time while considering the unique characteristics and preferences of the target population.

In addition to screen time, we observed a meaningful association between the outcomes and Walk Score. Notably, the association was contrary to expectations, as higher Walk Scores were associated with decreased MVPA. However, Walk Score may be less relevant for assessing children's physical activity levels than commonly believed (177). Walk Score considers features of the urban environment that may support adult walkability but have limited relevance to children's activity, such as shops, public transportation, movie theaters, libraries, and places of worship (177). Instead, it is important to consider built environment features that specifically support children's physical activity, such as broad sidewalks, dead-end streets, playgrounds, parks, and open spaces for play (178). Additionally, factors like perceptions of neighborhood safety from crime and traffic play a significant role in children and adolescents' physical activity but are not captured by Walk Score (208,209). For future research on neighborhood correlates, we recommend either examining the relationship of the relevant neighborhood characteristics separately with the outcomes or constructing a “neighborhood playability” index that accounts for features that are relevant to children and adolescent’s physical activity and sedentary behavior.

To further expand our knowledge on the correlates of children and adolescents' physical activity and sedentary behavior, we recommend a more comprehensive examination of potential correlates guided by an ecological framework (210). The ecological framework provides a holistic perspective by considering individual, social, environmental, and policy-level factors that influence physical activity and sedentary behavior. This comprehensive approach recognizes the complex interplay between multiple factors and their combined impact on children and adolescents' behaviors, making it well-suited for exploring the correlates of physical activity and sedentary behavior in a nuanced manner (210). Additionally, more sophisticated statistical approaches, such as penalization techniques including LASSO, LAR, and ridge regression, should be used to handle the issue of overfitting in regression models and identify the significant correlates accurately (161). By incorporating these insights into future research and intervention efforts, we can better support and promote physical activity among children and adolescents.

Conclusion

In summary, the results from this dissertation, which includes the ACTIWEB-PA study and SHOW study, provide valuable contributions to the field of children and adolescents' physical activity epidemiology. The ACTIWEB-PA study focuses on a yet untested remotely delivered, unsupervised eHealth intervention designed for children, providing important insights into the feasibility and potential impact of such interventions. By evaluating the intervention's outcomes and identifying areas for improvement, this study helps guide the development of future eHealth interventions aimed at promoting physical activity in this population. This study also addresses the need for innovative approaches to promote physical activity and improve health outcomes by capitalizing on the widespread use of the internet and digital devices among the young population. SHOW study on the other hand explores the correlates of children and adolescents' physical activity and sedentary behavior, shedding light on the factors that influence their activity levels. By identifying associations with variables such as screen time duration, Walk Score, BMI, and gender, this study offers valuable guidance for targeting specific subgroups and addressing key factors in future physical activity interventions.

Together, these studies advance the field of children and adolescents’ physical activity epidemiology by providing empirical evidence and insights that can inform the design, implementation, and evaluation of future interventions targeting children and adolescents. Taking into account the strengths and limitations of home-based eHealth approaches, incorporating recommendations to enhance their adherence and acceptability, targeting factors that influence physical activity, and tailoring interventions to cater to the specific needs of different subgroups, we can develop more effective interventions aimed at promoting physical activity and reducing sedentary behavior in this population.

Appendix

Appendix A: ACTIWEB-PA study results from mid and end-of-study intervention satisfaction surveys

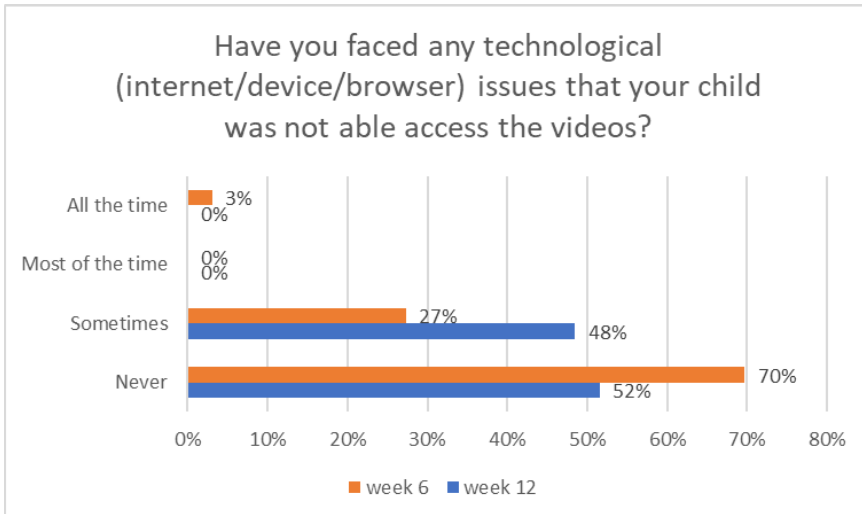


Figure 1: Perceptions on technological barriers

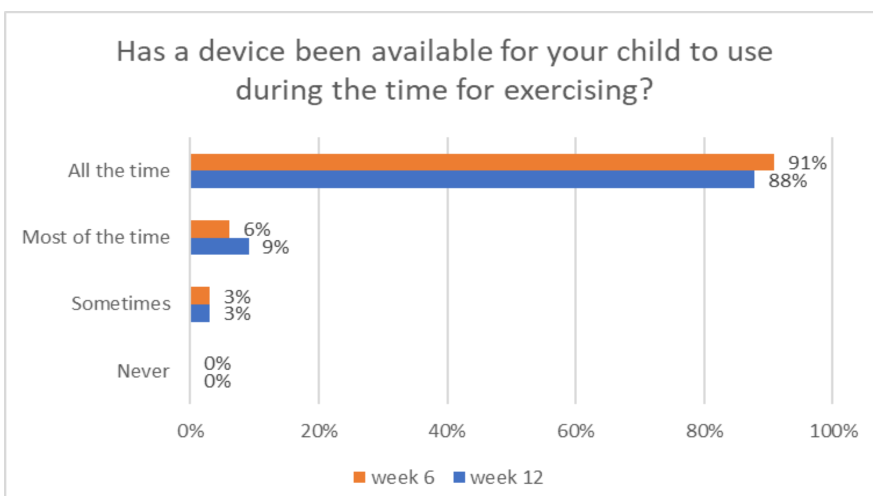


Figure 2: Perceptions on barriers related to device availability

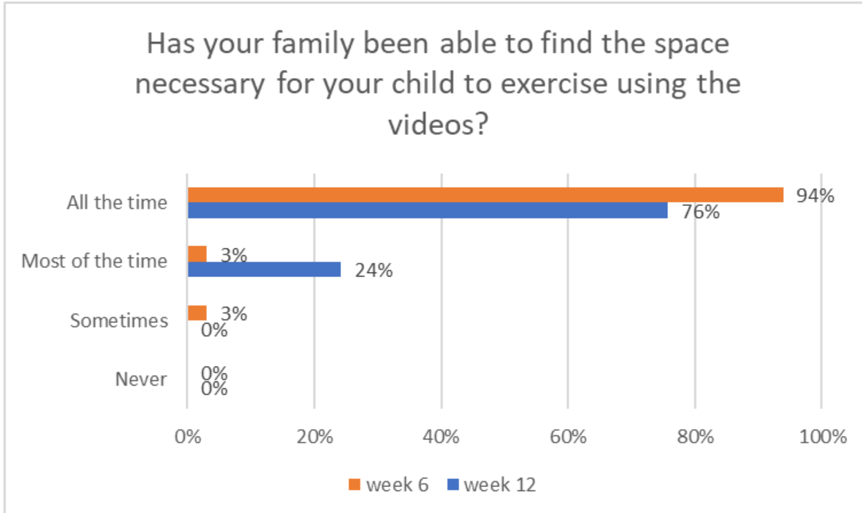


Figure 3: Perception on barriers related to space

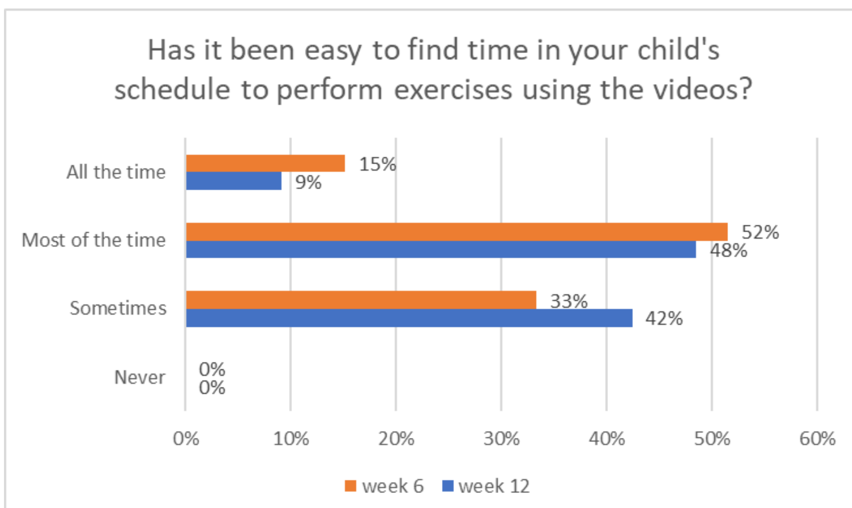


Figure 4: Perception on barriers related to time

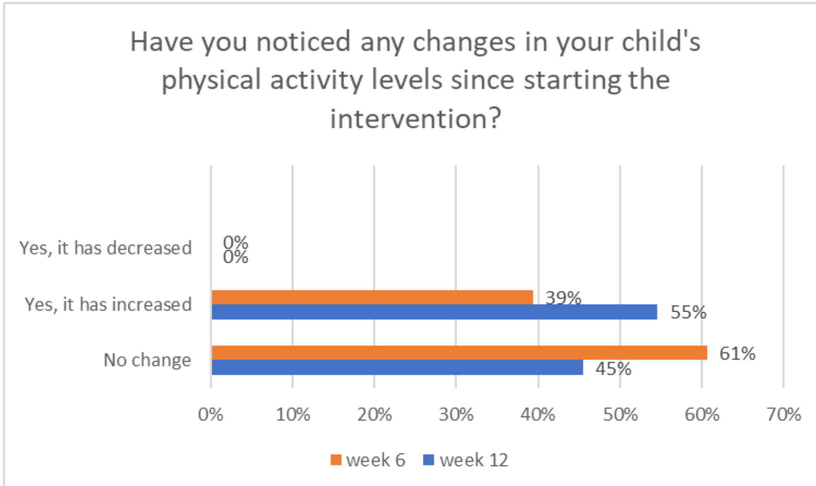


Figure 5: Perceptions on changes in physical activity

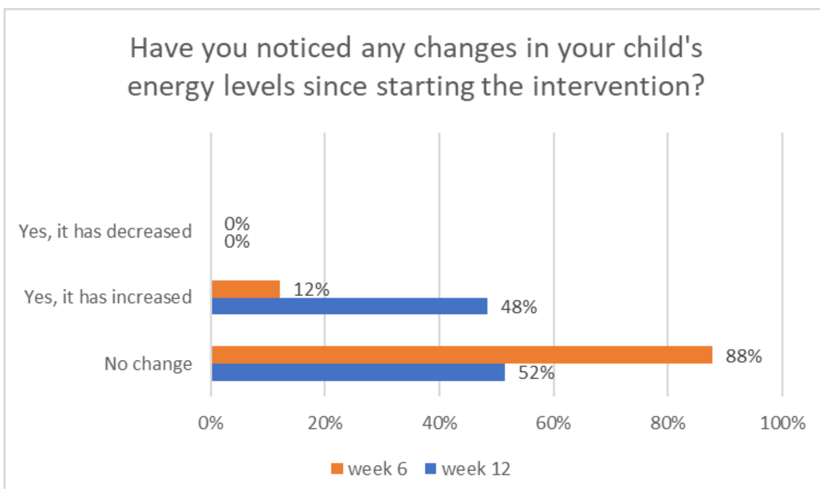


Figure 6: Perceptions on changes in energy levels

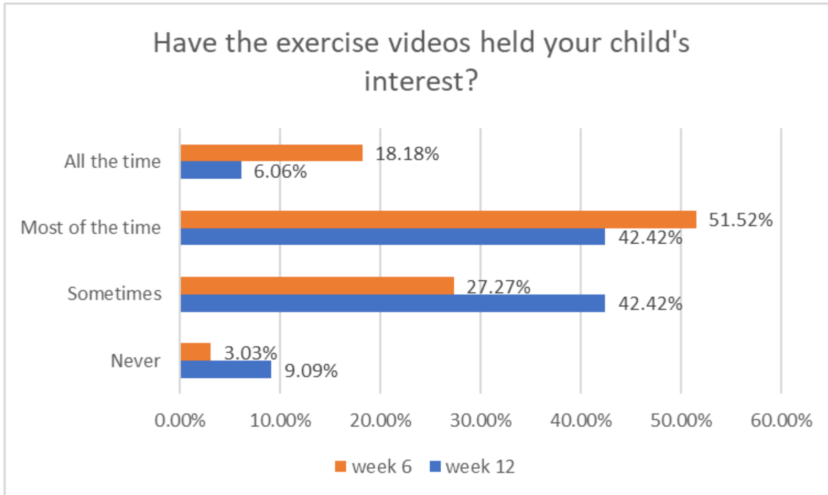


Figure 7: Perceptions on interest in the intervention

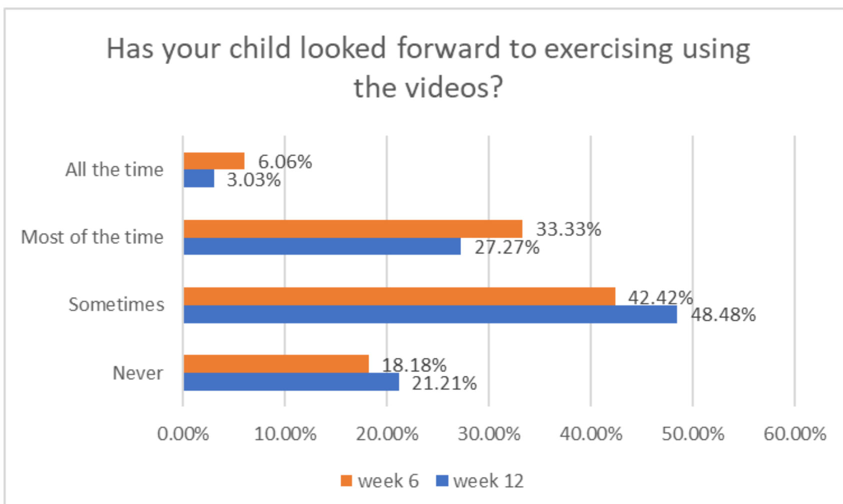


Figure 8: Perceptions on excitement to use the intervention

Appendix B: Intervention related material

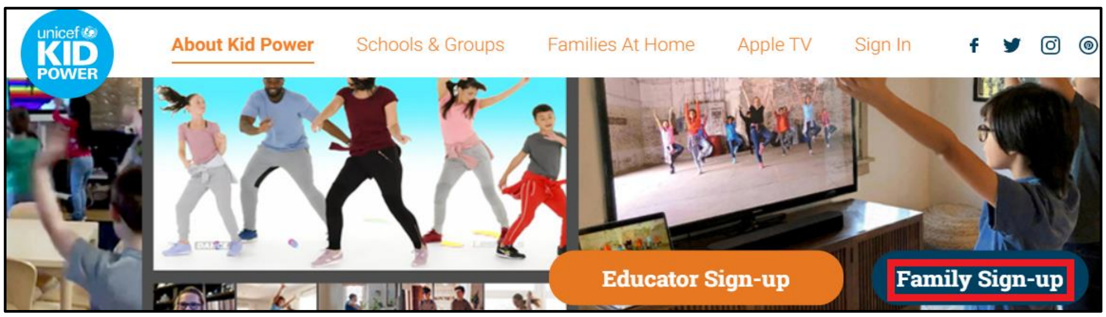
B1. Intervention Brochure shared during the instructional videocall with the EIG

ACTIWEB-PA: Instructions for parents on accessing and playing the exercise videos

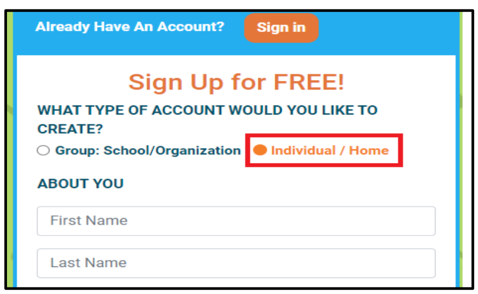
A. How to register with UNICEF Kid Power?

You will first need to register with **UNICEF Kid Power.** The steps below show you how to accomplish this. These steps need to be **done only a single time** at the start of the intervention.

1. Log onto **https://www.unicefkidpower.org/families-at-home/** on your internet browser using a laptop/desktop computer/electronic tablet/iPad/smartphone.
2. On the main page, sign up using the **'family sign up'** as shown below



3. Make sure you sign up for an **individual/home account** as shown below on the registration page



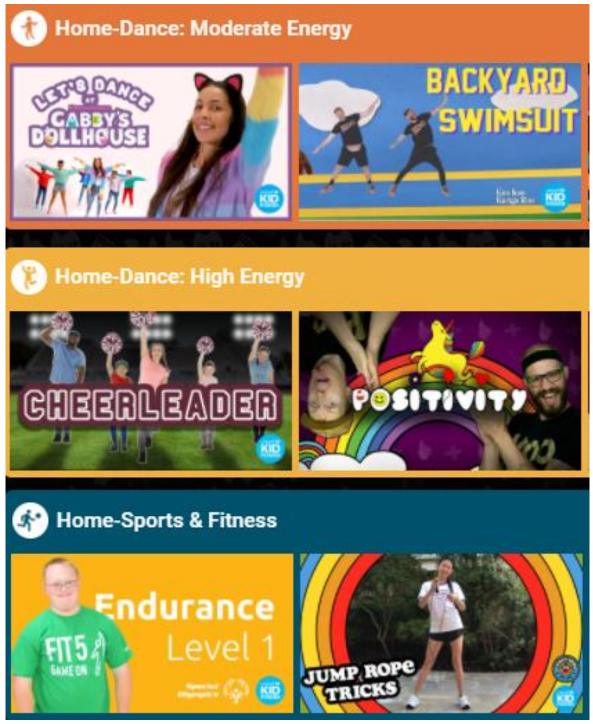
4. **Fill in the responses** to the questions that are asked to create an account and register with UNICEF Kid Power.
5. Following is the homepage that will appear once you are all signed up.

B. How to play the 5 exercise videos each day?

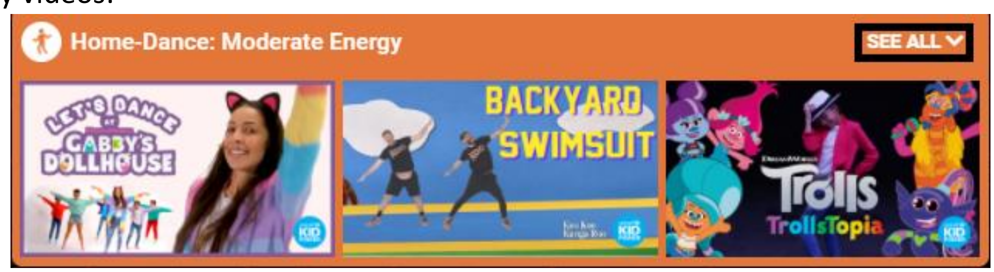
Your child will perform exercises on a total of **five self-selected videos on five days of the week (preferably from Monday to Friday but can be any 5 days of your family's choice) for 12 weeks.** The following steps instruct you on how to access the videos and play them.

1. On the homepage, the exercise videos are categorized in several categories. Your child can select and play any **5 videos** of his/her choice each day from the following three categories.
    a. **Home-dance: Moderate energy,**
    b. **Home-dance: High energy,**
    c. **Home: Sport & Fitness**

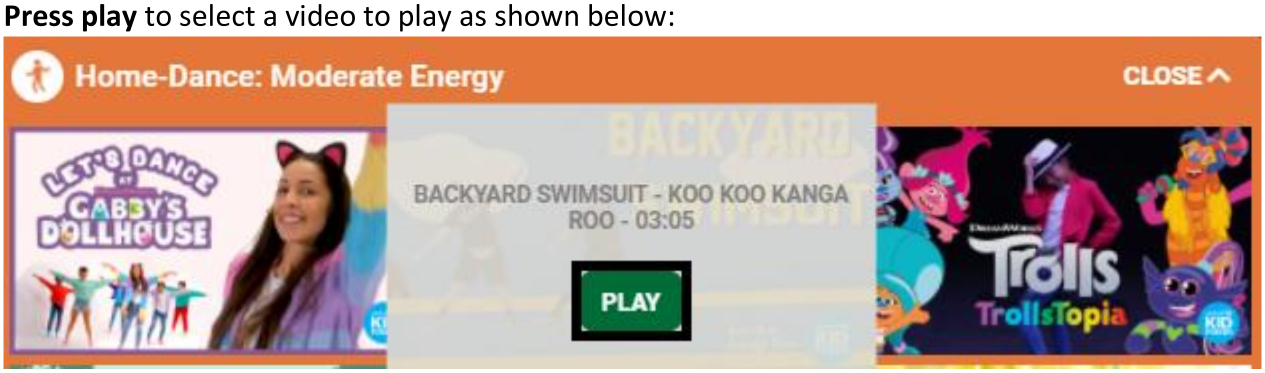
    Below are the images of the three categories that your child is expected to choose from:



2. Your child can expand the selection of videos in each category by clicking on the "SEE ALL" tab in the upper right-hand corner as shown below for Home-dance: Moderate energy videos:



3. **Press play** to select a video to play as shown below:



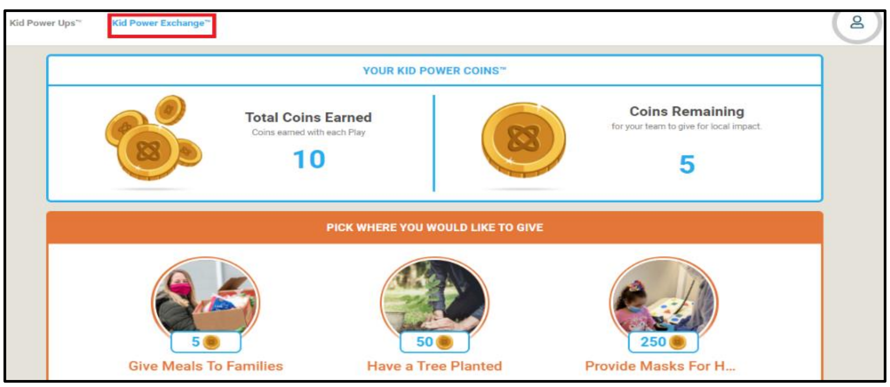
4. Your child will make **four more exercise video selections (five in total)** from the three categories as explained above each day.

5. Your child is expected to **actively follow the movements shown** in the videos and complete the videos in entirety before moving on to the next.
6. Once the five exercise videos from the three categories have been completed for the day, your child is free to play more videos/select videos from other categories such as Home-Yoga Meditation or Home-Connect.
7. Make sure to fill in the **exercise log survey** (the link to which will be sent as part of the weekly emails) at the **end of each week** of the intervention.

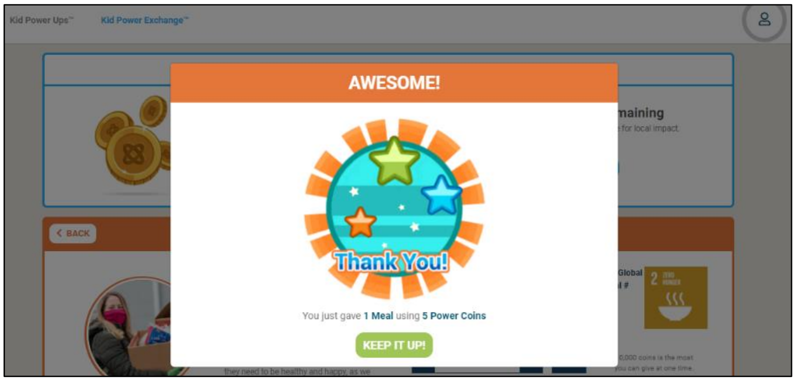
C. Impacting local and global community by participating in the intervention (OPTIONAL)

For every video that your child completes, she earns a coin. These coins can be added up and 'spent' on **buying meals, planting trees etc. in the local community.** The following steps illustrate how to 'spend' the coins your child earns. Although these steps are not necessary to the intervention, they may help with increasing the motivation to perform exercise.

1. Select **Kid Power Exchange** on the top left section of the main webpage. The following page will display



2. Your child may choose a cause from the ones listed and **'spend' her coins to benefit that cause**. Your child will receive a pop-up message thanking her for the contribution



3. For every 10 videos completed, a ready to use **therapeutic food (RUTF) packet** will be unlocked which will be delivered to malnourished children globally.

Important tips for parents for successful intervention participation

- It is important that the **child participates in the intervention 'actively'** which means that the child should follow the movements shown in the videos. Passive 'viewing' of videos will not confer exercise benefits.
- It is important that the child selects any 5 videos each day on 5 days of the week from the three categories of **Home-dance: Moderate energy, Home-dance: High energy, and Home: Sport & Fitness.**
- After the 5 videos have been completed as required by the ACTIWEB-PA intervention, the child is free to play more videos/from any other categories.
- Make sure there is **enough space** to allow for free bodily movements during exercise.
- It is recommended that the child exercises at roughly the **same time every day**. This helps in maintaining consistency and is helpful in fitting the exercises in the daily schedule.
- If **more than one child is participating** in the intervention from your family, they may exercise together using a single screen-based device
- When choosing a time to exercise, keep in mind that the **child should not be overly tired**. Avoid exercising towards the end of the day. A good time to exercise maybe **right before or after school/dinner** (to add it to the daily routine).
- Your child could split the exercises over **multiple sittings** in the day and need not perform in one bout.
- If the child does not feel like performing exercise on any day, **try participating in the exercises** with your child to make it a fun family activity.
- **Friends and/or siblings** (even if they are not part of the intervention study) can participate in the exercises with your child.
- Make sure that the screen-based device being used to access the videos is **charged and connected to the internet.**

Reminders for children for successful intervention participation

- Remember the numbers: **5-5-12,** which refer to:
    a. Perform exercises on **5 videos**,
    b. on **5 days of the week**
    c. for **12 weeks**.
- The 5 videos that you need to exercise on each day have to be chosen from the following **3 categories**:
    a. **Home-dance: Moderate energy,**
    b. **Home-dance: High energy,**
    c. **Home: Sport & Fitness.**
- Once you are done with the 5 videos for the day from these 3 categories, you may **play more videos as you like** from any other category on the website.
- Try to perform the exercises from **Monday to Friday** but if you miss a day, make up for it on a weekend.
- You may **split the exercises** over the course of the day (For example, 2 exercise videos in the morning and 3 in the evening).
- Remember to keep moving and exercising while the videos are on. Passively watching the videos is no fun.
- Remember, you earn **digital coins** with your exercise participation which you can use to help your community.
- To make it more fun, you may exercise with **friends, siblings, or your parents.**

B2: An example weekly reinforcement email sent to the EIG

Subject: Week 1 in ACTIWEB-PA intervention. Exercise log link.

Hi [parent name]!

Welcome to **week 1** of the ACTIWEB-PA study. At the end of week 1, please complete the exercise log here:

LINK

The federal physical activity guidelines recommend that children do 1 hour or more of moderate-to-vigorous physical activity daily. Regular physical activity in children is associated with improved fitness, lower body fat, stronger bones and muscles, brain health benefits, and reduced symptoms of depression. Regular physical activity in childhood promotes lifelong health by preventing health conditions like heart disease, obesity, and type 2 diabetes.

In addition to the regular physical activity performed by your child, participation in the ACTIWEB-PA study helps your child achieve the daily physical activity goal of 1 hour of moderate-to-vigorous physical activity. To maximize the benefits of participation in the study, it is important that [child name] undertakes the video-based exercises consistently for the duration of study.

We share a few tips that you can use to encourage [child name] to consistently exercise as part of the study-

- Talk to your child about the daily physical activity goal and the benefits of physical activity. Read more on the physical activity guidelines for youth here- **Physical activity guidelines for children**.
- Share this printable physical activity factsheet that can be hung in the child's room- **Physical Activity factsheet for children**.

We thank you once again for participating in the ACTIWEB-PA study. We hope that [child name] continues to actively participate in the study until completion.

We also ask that, in case of physical injuries or any other adverse events as a result of the participation in the study, please email us at bertramlab@education.wisc.edu or call us at (608) 262-3588.

Thank you for your continued participation.

The ACTIWEB-PA Study Team
Physical Activity Epidemiology Lab
353 Bardeen
1300 University Ave, Madison, WI

B3: An example weekly reinforcement email sent to the WCG

Subject: Week 1 in ACTIWEB-PA intervention.

Hello!

Welcome to **Week 1** of the ACTIWEB-PA study.

The dietary guidelines for Americans recommend that children and adolescents take a healthy diet that includes fruits and vegetables, whole grains, dairy products, and protein foods. These guidelines also recommend limiting calories from solid fats, added sugars, and reducing sodium intake. A healthy dietary pattern helps your child achieve a healthy body weight, consume important nutrients, and reduce the risk of developing chronic health conditions in future.

We share a few tips that you can use to encourage your child to follow a healthy dietary pattern-

- Educate your child on the different food groups that comprise a healthy diet. Read about the guidelines for a healthy diet here- **Dietary guidelines for children**.
- Share these fun, printable activity sheets with your child that teach about healthy diet- **Healthy diet maze** and **Create your menu**.

We thank you and your child once again for participating in the ACTIWEB-PA study. We hope that you continue to participate in the study until completion. In case of questions, email us at bertramlab@education.wisc.edu or call us at (608) 262-3588.

Thank you,

The ACTIWEB-PA Study Team
Physical Activity Epidemiology Lab
353 Bardeen
1300 University Ave
Madison, WI

Appendix C: Instruments

C1. Demographic, anthropometric, and health history questionnaire (parent-reported)

First name of the person completing the questionnaire:___________________________

Last name of the person completing the questionnaire______________

Relationship to the child Parent Other

Specify other ______________________

Child's general information:

1. Name of the child:
   ____
2. Date of birth of the child:
   ____
3. Sex of the child Male Female Other
4. Current School grade: First Second Third Fourth Fifth Sixth Seventh Not applicable
5. Current Address:
6. Current City:
7. Zipcode:
8. Ethnicity of the child
   Hispanic or Latino Not Hispanic or Latino Prefer not to say

9. Race of the child (Check all that apply)
   □ American Indian or Alaska Native
   □ Asian
   □ Black or African American
   □ Native Hawaiian or other Pacific Islander
   □ White
   □ Prefer not to say
10. Child living with (Check one that applies):
    □ parents (Cohabitating)
    □l mother only
    □ father only
    □ mother with stepfather
    □ father with stepmother
    □Other living arrangement
11. Specify the other living arrangement_____________________
12. Household Income per annum (Check one that applies):
    □ $24,999 and lower

☐ $25,000-$49,999
☐ $50,000-$99,999
☐$100,000-$199,999
☐ $200,000 and over
☐ Prefer not to say

Child's health Information:

13. Weight in lbs: ___________________
14. Height in inches: _________________
15. In the past 6 months, has your child had a chronic health condition (defined as a physical or mental health condition that has lasted or is expected to last at least 6 months, and interferes with your child's activities) (Circle one)?: No Yes

   If yes, what is the name of your child's chronic health condition? ____________
16. Has your child ever been diagnosed with any disability/impairment by a physician? If yes, what is the name of your child's disability? ________________

Father's Information

17. Is the father of the child alive: Yes No (if not then skip this section)
18. Date of Birth:____
19. Highest education level:

   None Elementary school Middle School High School Undergraduate Graduate
   Prefer not to say
20. Current job status? (Check all that apply).
   ☐ Employed full time (including self-employed)
   ☐ Employed part time (including self-employed)
   ☐ Retired (not due to health)
   ☐ Disabled and/or retired because of health
   ☐ Unemployed
   ☐ Student
   ☐ Homemaker- full time
   ☐ Other
21. Specify the other current job:______________________
22. In an average week, how many minutes of moderate to vigorous intensity aerobic physical activity does the father of the child perform? This includes activities that get heart rate up and cause to breathe harder like jogging, running, walking, bicycling (check one that applies):

   Less than 60 mins 60 to 89 mins 90 to 149 mins 150 minutes or more

Mother's information

23. Is the mother of the child alive: Yes No (if not then skip this section)
24. Date of Birth:
25. Highest education level

None Elementary school Middle School High School Undergraduate Graduate
Prefer not to say

26. Current job status? (Check all that apply).
    - ☐ Employed full time (including self-employed)
    - ☐ Employed part time (including self-employed)
    - ☐ Retired (not due to health)
    - ☐ Disabled and/or retired because of health
    - ☐ Unemployed
    - ☐ Student
    - ☐ Homemaker- full time
    - ☐ Other
27. Specify the other current job: ________________________
28. Occupation:____
29. In an average week, how many minutes of moderate to vigorous intensity aerobic physical activity does the mother of the child perform? This includes activities that get heart rate up and cause to breathe harder like jogging, running, walking, bicycling (check one that applies):
    Less than 60 mins 60 to 89 mins 90 to 149 mins 150 minutes or more N/A
30. Do you have another child between 8-11 years participating in this study?
    No Yes

Thank you for your time in completing this survey.

C2. Physical functioning and psychosocial health questionnaire (PedsQL)- child reported

These questions ask you how you feel and what you think about your health. It is not a test, and there are no right or wrong answers. When you answer a question, think about how you really are and not how you should be. It takes about 5 minutes to complete. If you do not understand a question, please ask for help.

Directions- On the following page is a list of things that might be a problem for you. Please tell us how much of a problem each one has been for you during the past ONE month by selecting one of the following.

- Never a problem
- Almost never a problem
- Sometimes a problem
- Often a problem
- Almost always a problem

Please try and answer each question, even if some are hard to decide. Remember that there are no right or wrong answers. Only you can tell us about your health, so we hope you will select what you really feel inside.

Thank you!

*In the past **ONE month**, how much of a **problem** has this been for you …*

ABOUT MY HEALTH AND ACTIVITIES *(problems with…)*	Never	Almost Never	Some-times	Often	Almost Always
1. It is hard for me to walk more than one block	0	1	2	3	4
2. It is hard for me to run	0	1	2	3	4
3. It is hard for me to do sports activity or exercise	0	1	2	3	4
4. It is hard for me to lift something heavy	0	1	2	3	4
5. It is hard for me to take a bath or shower by myself	0	1	2	3	4
6. It is hard for me to do chores around the house	0	1	2	3	4
7. I hurt or ache	0	1	2	3	4
8. I have low energy	0	1	2	3	4

ABOUT MY FEELINGS *(problems with…)*	Never	Almost Never	Some-times	Often	Almost Always
1. I feel afraid or scared	0	1	2	3	4
2. I feel sad or blue	0	1	2	3	4
3. I feel angry	0	1	2	3	4
4. I have trouble sleeping	0	1	2	3	4
5. I worry about what will happen to me	0	1	2	3	4

HOW I GET ALONG WITH OTHERS *(problems with…)*	Never	Almost Never	Some-times	Often	Almost Always
1. I have trouble getting along with other kids	0	1	2	3	4
2. Other kids do not want to be my friend	0	1	2	3	4
3. Other kids tease me	0	1	2	3	4
4. I cannot do things that other kids my age can do	0	1	2	3	4
5. It is hard to keep up when I play with other kids	0	1	2	3	4

ABOUT SCHOOL *(problems with…)*	Never	Almost Never	Some-times	Often	Almost Always
1. It is hard to pay attention in class	0	1	2	3	4
2. I forget things	0	1	2	3	4
3. I have trouble keeping up with my schoolwork	0	1	2	3	4
4. I miss school because of not feeling well	0	1	2	3	4
5. I miss school to go to the doctor or hospital	0	1	2	3	4

C3. Self-Concept questionnaire (Piers-Harris)- child reported

These questions ask you how you feel and what you think about yourself. It is not a test, and there are no right or wrong answers. When you answer a question, think about how you really are and not how you should be. Before starting this survey, make sure you are in a quiet room away from any distractions. It takes about 10-15 minutes to complete.

Directions- Here are some sentences that tell how people may feel about themselves. Read each sentence and decide whether or not it describes the way you feel about yourself. If it is true or mostly true for you select the word yes. If it is false or mostly false for you select the word no. Please try and answer each question, even if some are hard to decide. Remember that there are no right or wrong answers. Do not take help to answer. Only you can tell us how you feel about yourself, so we hope you will select each answer the way you really feel inside.

Thank you!

1. I am popular.	Yes	No
2. My friends like my ideas.	Yes	No
3. I worry that people will make fun of me.	Yes	No
4. I am easy to get along with.	Yes	No
5. I have a nice face.	Yes	No
6. I sit alone at lunch.	Yes	No
7. I get nervous when the teacher calls on me.	Yes	No
8. My family is disappointed in me.	Yes	No
9. I am excited about the future.	Yes	No
10. My classmates make fun of me.	Yes	No
11. I hate school.	Yes	No
12. I don't like the way I look.	Yes	No
13. I get worried when we have tests in school.	Yes	No
14. I am unhappy.	Yes	No
15. My classmates in school think I have good ideas.	Yes	No
16. I participate in school activities.	Yes	No
17. I am smart.	Yes	No
18. I worry a lot.	Yes	No
19. I think bad thoughts.	Yes	No
20. I can give a good report in front of the class.	Yes	No
21. I am a good person.	Yes	No
22. I am not popular.	Yes	No
23. I forget what I learn.	Yes	No

24. It is usually my fault when something goes wrong.	Yes	No
25. I wish I were different.	Yes	No
26. I am cheerful.	Yes	No
27. I get into a lot of fights.	Yes	No
28. I am a happy person.	Yes	No
29. I am often afraid.	Yes	No
30. I like my hair.	Yes	No
31. I am nervous.	Yes	No
32. I have a hard time finishing my homework.	Yes	No
33. I do many bad things.	Yes	No
34. I cry easily.	Yes	No
35. It is hard for me to listen in class.	Yes	No
36. I daydream at school.	Yes	No
37. I behave badly at home.	Yes	No
38. I am lucky.	Yes	No
39. I am a good reader.	Yes	No
40. I feel alone.	Yes	No
41. I cause trouble to my family.	Yes	No
42. I have a hard time finishing my work at school.	Yes	No
43. I am often sad.	Yes	No
44. My parents (or caregivers) expect too much of me.	Yes	No
45. I like my body.	Yes	No
46. It is hard for me to follow in class.	Yes	No
47. I am an important member of my class.	Yes	No
48. I am among the last to be chosen for games and sports.	Yes	No
49. I cause trouble at home.	Yes	No
50. I have many friends.	Yes	No
51. I like the way I am.	Yes	No
52. It is hard for me to make friends.	Yes	No
53. I am strong.	Yes	No
54. I am ashamed of myself.	Yes	No
55. People bully me.	Yes	No
56. I like my size.	Yes	No
57. I am shy.	Yes	No
58. I am dumb about most things.	Yes	No

C4. An example exercise log

Page 1

Week1 Exercise Log

Please complete the survey below.

Thank you!

1) Participant's (child's) first name ______________________

In the questions below, please record the number of days that the child exercised, and the number of UNICEF Kid Power videos exercised on. When reporting this, please recall only those videos that were part of the three categories of Home-dance: Moderate energy, Home-dance: High energy, and Home: Sport & Fitness.
Please also provide any comments on the child's participation during the past week including any reasons for non-participation.
If more than one child from your family is participating in the study, please fill a separate log for each child.

2) In the past week, how many days did your child exercise using UNICEF Kid Power videos? ______________________

3) In the past week, how many total UNICEF Kid Power videos did your child do? ______________________

4) In the past week, please note any difficulties experienced, reasons for non-participation, or other comments ______________________

C5. Videocall script and interview prompts for the end-of-study interview

(If there are more than 1 child participating, make sure to address all the children throughout the document)

Hello (parent name) and (child name)! This is (your first name) from the University of Wisconsin with the ACTIWEB-PA Study! How are you today? *(Exchange general pleasantries).*

I would also like to share with you that this interview is audio recorded and transcribed for content but will be used in a de-identified manner. This means that no personal identifiers such as names, address, or phone numbers will be associated with your responses.

The purpose of today's call is to understand your experiences with the ACTIWEB-PA study, what worked for you and what did not, and what could be improved so we can better design future research studies. There are no right or wrong answers. Please be as open and honest as possible, as any and all feedback will help to improve future studies.

I will first interview you for the first 15 minutes and then ask (child name) questions about his/her experiences later.

Questions for parents

We will get started now. These questions are for you, the *mother/father/another relation* of (child name).

These questions ask you about your thoughts, beliefs, and opinions about the exercise video intervention program. Please be as honest as possible so we can be sure to improve our methods for future studies.

1. What was your <u>favorite</u> part of this intervention and the most <u>burdensome</u> part of the exercise intervention?
   When answering these, think about the exercise video prescription- the content, duration and frequency, ease of accessing & playing the prescribed videos, any technical challenges you faced, ease of use of website, inbuilt reward system, and the weekly newsletter.
2. Did your child encounter any <u>barriers/challenges</u> to exercising as part of intervention? (What were some things that made it hard for your child to exercise as part of the intervention?)

3. What were some things- ideas or strategies that made it easy for your child to exercise as part of the intervention?
4. What was it like finding time in your schedule to support your child to do the exercises?
5. How did your child find the time for the intervention?
6. What did you think of the weekly newsletter? Do you have any comments on their content, frequency, and usefulness?
7. Has your child's use of UNICEF kid Power exercise videos increased or decreased since the start of the exercise intervention? If so, could you please explain the reasons behind the change in use?
8. Has your child's overall physical activity increased or decreased over the past weeks? If so, can you explain in what ways it has increased or decreased?
9. In what ways could the intervention change for the better?
   The next few questions ask you about child's experience with wearing the ActiGraph monitor:
10. How was your child's experience with using the ActiGraph monitor?
11. In your opinion, what was your child's favorite part and the most burdensome part of using the ActiGraph monitor?
12. How was your experience with reporting ActiGraph wear time?
13. In what ways could the ActiGraph component change for the better?
14. Do you have any other experiences and feedback about the study that you would like to share that may help with future research designs?

Thank you very much for sharing your honest thoughts on our research study. Your feedback is very valuable and will be helpful in improving our future study methods.

Questions for children

(If there are more than 1 child participating, make sure to address all the children throughout the document)

Now I will ask (child name) about his/her thoughts on participating in the exercise program. (Child name), these questions ask how you feel about the exercise program. There are no right or wrong answers. You can share your thoughts honestly. Your answers will help us improve our future studies.

1. What was your <u>favorite part</u> of exercising/dancing using the videos?
2. What was the most <u>difficult part</u> of exercising/dancing using the videos?
3. <u>How excited</u> were you each day to exercise using the videos?
4. What were some things that made you <u>want to exercise</u> using the videos? (if you did the exercises, why did you do them? What motivated you to do them?)
5. What were some things that made you <u>not want to exercise</u> using the videos? (if you did not want to exercise what were the reasons you didn't want to do them?)
6. What could improve your experience with exercising using the videos?
7. Have you become more or less active since joining the study? Explain how?

Now, let me ask you of your experience wearing the ActiGraph tracker on your waist:

8. How was your experience with wearing the ActiGraph monitor?
9. What was your favorite part of wearing the ActiGraph monitor?
10. What was the most difficult part of wearing the ActiGraph monitor?
11. How could we improve your experience with wearing the ActiGraph monitor?
12. Would you like to share any other experience about participating in the exercises video program?

Thank you very much (child name) for sharing your honest thoughts on our research study. Your answers will help the study team design improved research studies.

If you have any questions or concerns after we finish the video call, please do not hesitate to contact us at any time! Our email is bertramlab@education.wisc.edu and our number is (608) 262-3588. It was so nice meeting you and (child name). Have a great day!

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