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Changes in Physical Activity and Sedentary Behavior in a Randomized Trial of an Internet-Based Versus Workbook-Based Family Intervention Study

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Abstract

Background—The America on the Move (AOM) Family Intervention Program has been shown to prevent excess weight gain in overweight children. Providing intervention materials via the internet would have the potential to reach more families but may increase sedentary behavior. The purpose was to evaluate whether delivering the AOM Family Intervention via the internet versus printed workbook would have a similar impact on sedentary behaviors in children.

Methods—131 children (age 8–12) were randomized to receive the AOM Family Intervention via the internet or workbook for 12 weeks. Changes in objectively measured sedentary time and moderate-to vigorous physical activity (MVPA) as well as self-reported screen time were compared between groups.

Results—There were no significant differences between groups in screen time, sedentary time, or MVPA at the end of the 12 week intervention. Families receiving the intervention via the internet were more likely to remain in the study (98% vs. 82%, $P = .016$).

Conclusions—Using the internet to deliver the lifestyle intervention did not increase sedentary behavior in children. Attrition rates were lower when the program was delivered by internet versus via printed materials. These results provide support for using the internet to deliver healthy lifestyle programs for children.

Keywords

childhood obesity; obesity prevention; weight gain; lifestyle intervention; accelerometry

Despite widespread awareness of the problem of obesity and its consequences, and despite increasing efforts to address the problem, obesity rates remain high. The increase in childhood obesity observed in the 1980s and 1990s is particularly alarming, as it is paralleled by an increase in the prevalence of weight-related medical problems previously unheard of in children including type 2 diabetes, hypertension, dyslipidemia, fatty liver disease, pulmonary complications (eg, asthma, sleep apnea), and musculoskeletal problems.[1,2] The prevalence of obesity in US children and adolescents ages 2–19 currently approaches 17%.[3] Although recent data suggests obesity rates in children may be stabilizing in females and preadolescent males[3] there remains a critical need for effective programs to begin to reverse the high rates of childhood obesity.

Although there is agreement about the urgent need to address the epidemic of obesity in children, there is not agreement about how to do this. Many experts believe we may have more success in preventing obesity than in reversing it once it is established. Hill et al[4] suggested that a strategy of preventing excessive weight gain may be more feasible than a strategy of weight reduction for the entire population. Data from Wang et al[5] found that excessive weight gain in children seems to be attributable, on average, to an extra 630 kJ/day (150 kcal/day), suggesting that small lifestyle changes can be used to prevent excessive weight gain in children and adolescents as well.

The importance and effectiveness of family-based childhood overweight prevention programs has been demonstrated in several studies,[6,7] and experts have recommended a family-based approach as the best way to address excessive weight in children.[8] As a result, The America On the Move Foundation (AOM) has created a program that helps Americans prevent excessive weight gain, via 1) reducing energy intake by 420 kJ/day (100 kcal/day) and 2) increasing physical activity (walking) by 2000 steps per day.[9] We have shown in 2 studies[10,11] that the AOM program is effective in preventing excessive weight gain in families with at least 1 child who was overweight or at risk for overweight. The results of these studies suggest that emphasizing small changes, when provided as a family intervention, can help to reduce excessive weight gain in children who are overweight or at risk for overweight.

In our earlier studies, the AOM Family program was delivered primarily via a printed, self-guided, step-by-step workbook provided to the families. In each weekly workbook chapter, families and kids were given activities, games and/or recipes to encourage healthy lifestyles. The workbook also contained a step goal to accomplish each week. We are currently interested in providing the AOM Family Program in an internet based format. The proliferation of the internet provides a powerful mechanism to widen the reach of interventions in children.[12] In 2009, 93% of US children had access to a computer at home.[13] An internet format would allow the AOM Family program to be more widely available to interested participants and to be provided in a more cost effective manner.[14]

However, providing an intervention via an internet based format could have unintended negative consequences by leading to increases in computer usage. Internet and computer use are increasingly common leisure-time activities in children which have the potential to impact negatively on health by increasing sedentary time and decreasing physical activity.[15,16] While a small increase in computer time is expected when an intervention is delivered via an internet format, it is possible that providing an intervention via the internet could serve as a "gateway" to increased computer use. For example once a child logs on to the computer to participate in the internet based intervention, they might be more likely to engage in other activities on the computer which could increase overall sedentary behavior with potential adverse health effects. Increased computer use could also displace time spent in leisure time physical activity. While a number of studies have evaluated the efficacy of internet based interventions for promoting physical activity behavior in children,[17] no studies we are aware of have evaluated the impact of internet based interventions on sedentary time in children. For this reason, we felt it would be important to evaluate whether providing a healthy lifestyle intervention via the internet could lead to detrimental changes in sedentary behavior. Our ultimate goal was to address the possibility that using a sedentary technique (the internet) to promote physical activity could be counterproductive.

Therefore, the primary aim of this study was to evaluate whether providing the AOM family intervention in an internet based format as compared with the traditional printed workbook format would impact sedentary behaviors in both overweight and normal weight children. We chose to include both normal weight and overweight children in the study as the AOM as the aim of the AOM program is to prevent excess weight gain and reduce risk of becoming overweight in normal weight children, as well as reduce further weight gain in already overweight and obese children. A secondary aim was to evaluate whether providing the AOM family intervention in an internet based format as compared with a printed workbook format would impact objectively measured time spent in moderate-to-vigorous physical activity (MVPA) in both overweight and normal weight children. We hypothesized that providing the AOM family intervention in an internet based format as compared with the traditional printed workbook format would not have a detrimental impact on either sedentary behavior or physical activity in overweight and normal weight children.

Methods

Study Design

We randomly assigned 98 families to receive the AOM family intervention in a Workbook Based (WB) Format (n = 49 families, 69 children) or an Internet Based (IB) format (n = 49 families, 62 children). Families in both groups were asked to make 2 small lifestyle changes consisting of 1) increasing daily walking by 4000 steps/day above baseline levels and 2) decreasing energy intake by 420 kJ/day (100 kcal/day) from baseline levels. In our prior 24 week AOM family study[11] families were encouraged to increase steps by 2000 per day. Although participants did report significantly more steps/d than baseline throughout the study, neither children nor adults in the intervention reached the target 2000 steps/day increase. A recent meta-analysis has suggested studies using higher step goals (ie, 10,000 steps/day) were found to have a greater effect size on steps/day at the end of the intervention than studies using individualized goals.[18] Therefore, in the current study, we chose to target a higher step goal (an increase of 4000 steps/day) in hopes that this would increase achievement of the actual desired step goal (an increase of 2000 steps/day).

Both groups received the same intervention content but differed only in the format in which the intervention was delivered (internet versus workbook). After a 1 week baseline period, families were studied for 12 weeks. Outcomes (sedentary behavior logs; objectively measured time spent in sedentary and moderate-to-vigorous physical activity) were assessed during the baseline week and during weeks 6 and 12. Recruitment and data collection were completed between August 2010 and March 2011 at the University of Colorado–Denver.

Participants and Selection Criteria

The primary inclusion criteria were children age 8–12 whom had and were comfortable using a computer with access to the internet at home. As the AOM family program is not a weight loss program and is designed to aid both normal weight and overweight individuals to live more healthfully, there was no target range for percentile BMI-for-age. The participant's family must have been willing to follow the AOM family program, and the child must reside in the household more than 50% of the time. In addition, the participant's parent(s)/guardian(s) agreed not to make any changes to the participant's permitted level of physical/sedentary activity unrelated to the AOM intervention during the study (ie, they cannot change the amount of TV the participant is allowed to watch). Children with physical or medical limitations that limited their ability to perform physical activity were excluded. All children in the family of the target age range were invited to participate.

Recruitment methods included distributing flyers through schools, recreational centers, doctors' offices, and community events. After a scripted phone screening, eligible families attended an in-person screening during which the study's purpose and requirements were fully discussed and eligibility was confirmed. Written informed consent was obtained from the parents and the study was approved by the Colorado Multiple Institution Review Board. Randomization occurred during the baseline visit, once eligibility was confirmed. Only the study biostatistician had access to the predetermined randomization schedule, such that assignments were masked to the investigators, study staff, and participants until time of randomization. Qualifying families with more than 1 child in the target age range were randomized together. A total of 139 families were phone screened for the study; 101 families (66 girls and 68 boys) attended an in person screening visit and 98 families (65 girls and 66 boys) completed baseline measures and were randomized to participate in the 12 week study. 68.4% of families had 1 child who participated in the study, 30.6% had 2 children and 1% had 3 children.

Interventions

All families were asked to make 2 small lifestyle changes in the area of physical activity and diet.

Physical Activity—All participants were given pedometers and were asked to wear pedometers during the 12 week intervention period (excluding the baseline week). After establishing an average initial activity level (steps/day) during week 1, each participant was instructed to increase his or her daily physical activity from week 1 levels as follows: increase by 2000 steps/day during weeks 2 to 4, by 2500 steps/day during weeks 5 to 6, by 3000 steps/day during weeks 7 to 8, by 3500 steps/day during weeks 9 to 10, and by 4000 steps/day during weeks 11 to 12. To encourage step goal attainment, families were given a list of simple ways to increase steps (eg, park farther away, walk the family dog, use the stairs instead of the elevator or escalator), ideas for outdoor/indoor physical activities, and charts with which to track their progress.

Dietary Change—Each participant was instructed to eliminate 420 kJ/day (100 kcal/day) from his or her usual diet. To encourage dietary goal attainment, families were given a list of simple ways to decrease 100 calories, for example by reducing their sugar and fat intake, or by decreasing the portion size of their meals.

Intervention Delivery

The above small changes message (AOM Family Program) was delivered via 1 of 2 avenues: the AOM website; or a printed, self-guided, step-by-step workbook. Families in both groups were sent emails once per week reminding them to continue their progress in the program.

Workbook Based Intervention (WB)—Children (and parents) were given copies of the America on the Move Family Program workbook. During the baseline visit families were oriented to their workbooks and were given pedometers. Families were also provided with instructions on how to properly use pedometers to keep track of their daily steps. The workbook is broken down into 12 chapters—1 chapter per week. In each chapter, families and kids were given activities, games and/or recipes to encourage healthy lifestyles. The workbook also contained a step goal to accomplish each week per the above protocol. Kids were asked to log their steps each week in the family workbook.

Internet Based Intervention (IB)—Children (and parents) were given access to the America on the Move website and added to an interactive group of study participants with a private webpage. They accessed this page by signing into the AOM homepage and following a link to the study group. This group page was exclusive to study participants and could not be accessed by the general public. During the baseline visit, they were oriented to the website and were given pedometers. Families were provided with instructions on how to properly use pedometers to keep track of their steps and participants were asked to log their steps on the AOM website. The website was updated each week to correspond to information provided in the workbook. Each week, families were given activities, games and/or recipes to encourage healthy lifestyles (identical to the activities in the workbook).

Outcome Measures and Methods of Assessment

Screen Time—Screen time (time spent watching television, using a computer, or playing videogames) was assessed with an in-person, interview-based 24-hour behavior recall. Subjects were shown a log by study staff and were asked to think about the previous day and, for each hour of the day, to identify all 15 minute intervals in which they a) watched

TV, b) were sitting in front of the computer, or c) played video games. These logs were completed with participants twice (once when the accelerometer was initialized and once when it was returned) during each measurement period (baseline, week 6 and week 12). Total daily screen time was summed for each of the 24 hour periods.

Physical Activity and Inactivity—The Actical (Mini Mitter Co, Inc, Bend Oregon) omnidirectional accelerometer was used to provide an objective measure of physical activity and sedentary time over a 1-week period at baseline, weeks 6 and 12. Technical specifications of the device have been described in detail elsewhere.[19] Participants were asked to wear the accelerometer continuously for a 1 week period. The Actical accelerometers are designed to be waterproof and were not removed for bathing or water activities. The device was attached to the participants' wrists using Soft Comfort WF MedTech Wristbands. The participant was not able to turn off the unit; and data were collected continuously by the device. The participant was not able to see activity counts recorded by the unit. The data collection mode for the accelerometer was set to record activity counts every 15 seconds (15 sec epoch).

Data were analyzed during waking hours standardized as a 17-hour window between 6 AM and 11 PM. Data for a given day were considered valid if the accelerometer was worn for ≥ 10 hours (600 min), which is consistent with previously published recommendations for the use of an accelerometer to measure physical activity[20] and with prior studies of children of this age range.[21] Accelerometer nonwear was defined as ≥ 60 continuous minutes of activity counts of 0 on the accelerometer, Subjects were required to have at least 4 valid days of accelerometry data including at least 1 weekend day to be included in the analysis, consistent with previously published recommendations for the use of an accelerometer to measure physical activity in children of this age range.[22]

Because only 1 other group has established intensity cut-points and validated the Actical for wrist placement in older children (8–14 years)[23] we elected to conduct a calibration/validation experiment in our laboratory. Briefly, 22 children (12 girls, 10 boys) ages 6–11 (mean age 8.72 years, BMI range 14.1–25.0) were fitted with the Oxycon Mobile portable metabolic cart (Care Fusion, Yorba Linda, CA) and an Actical accelerometer on the nondominant wrist. After a period of 20 minutes of quiet rest, each child performed a variety of tasks for 6 minutes each, including coloring, quiet standing, light aerobics, slow walking (0.75 m/s), fast walking (1.5 m/s), four-square, jogging (2.0 m/s), and jumping rope. We used the WHO/FAO/UNU equation for estimating resting energy expenditure to determine subject-specific resting metabolic rate.[24] We then divided measured VO_2 values for each activity by the predicted resting value to determine METs. Linear regression was used to determine appropriate accelerometry count cutpoints associated with sedentary (< 1.5 METs), light (1.5–2.99 METs), moderate (3–5.99 METs), and vigorous (≥ 6 METs) activity. The count/15-sec epoch thresholds identified are as follows: sedentary = ≤ 21; light = 22–620; moderate = 621–1817; vigorous = ≥ 1818. Based on these thresholds, we calculated total minutes per day within the sedentary activity range (≤ 21 counts per 15-sec epoch) and within the moderate-to-vigorous activity range (≥ 620 counts per 15-sec epoch). We also calculated total activity level (mean counts/minute over the entire period of time the device was worn) and mean MPVA intensity (counts/min during time within the MVPA range).

Statistical Analysis

All data analyses were performed with SAS Version 9.2 (SAS Institute, Inc., Cary, NC). A 2-sided alpha level of 0.05 was used to assess statistical significance. Chi-square tests and independent samples *t* tests were used to compare baseline characteristics between those randomized to internet versus workbook. Fisher's Exact Test was used to compare attrition rates. Linear mixed effects models were used to analyze average screen time per day measured by the Sedentary Behavior Log, sedentary time measured by the Actical, and the amount of time spent performing moderate to vigorous physical activity (MVPA) measured by the Actical. Linear mixed effects models allow for missing outcome data and account for the correlation within families and between the repeated measures on the same individual. Study time (baseline, 6 weeks, 12 weeks), study group (internet, workbook), and the time × study group interaction were included as categorical fixed effects. A random family effect was included to account for multiple children per family. A Kronecker covariance structure (TYPE = UN@CS) was used for the repeated measures on an individual (3 time points × 2 behavior logs at each time point for modeling screen time; 3 time points × 4 to 6 daily measurements at each time point for modeling MVPA and sedentary time). The covariance matrix was estimated separately for each study group to allow for heterogeneous covariance structures across the groups. ESTIMATE statements were used for making all within and between group comparisons.

Subjects entered the study over a 6-month period from August through early January with follow-up assessments completed in October through March respectively. This time frame was chosen to correlate with the Denver Public School Calendar so that the majority of subjects were in school during the assessment period. However, seasonal variation has been shown to be a factor in children's activity levels with higher levels of activity in the summer versus winter.[21,25,26] A second set of linear mixed effects models were fit for each outcome adjusting for calendar month, sex, age, and BMI-for-age z-score to account for seasonal changes in screen time, sedentary time and MVPA during the winter months and to increase efficiency by adjusting for other factors associated with the outcomes of interest.

We calculated a priori that with a sample size of 40 completers in each group, the precision of our estimate for the between-group difference in screen time, sedentary time and MVPA time would be ± 13.4 minutes (ie, the half-width of the 95% confidence intervals would be 13.4 minutes). This calculation assumed a standard deviation of 30 minutes per day for screen time and sedentary time[27] and accelerometer measured MVPA[28] in children. The observed standard deviation for MVPA time (±28 min per day) was very close to predicted, thus our study was powered to detect a difference of 15 min/day in MVPA time between groups. However, the observed standard deviations in weekly screen time (±109 min/day) and sedentary time (±65 min/day) were higher than anticipated and thus the half-widths of the 95% Confidence Intervals are much larger than expected.

Results

Subject Characteristics

There were no statistically significant differences in baseline characteristics (including age, gender, ethnicity, anthropometric measures, number of children per family, baseline measures of screen time, sedentary time, or MVPA) between those randomized to receive the intervention via the internet and those randomized to receive the intervention via workbook (see Table 1).

Attrition Rates and Receipt of Intervention

There was a significant difference in the drop-out rate between the 2 study groups. Families receiving the intervention via the internet were more likely to complete outcome measures than those receiving the intervention via workbooks. Ninety-eight percent (48/49) of families randomized to the internet completed the study, compared with only 82% (40/49) of families randomized to the workbooks (Fisher Exact Test: $P = .016$). Families in the IB group logged on to the AOM website 17.9 ±12.0 times over the 12 week study. Screen time was recorded during each login to the AOM website, however, some participants did not log out of the website and thus website screen time was not analyzed. Data regarding completion of workbook exercises was not collected in the WB families.

Self Reported Screen Time

At baseline, children in the WB group reported an average of approximately 137 minutes of screen time/day, subjects in the IB group reported an average of 110 minutes screen time/day. This difference was not significant ($P = .222$). Subjects in the IB group had significantly less screen time at week 6 ($P = .035$), however there was no difference ($P = .973$) between groups at week 12. Average change in screen time from baseline to week 6, and from baseline to week 12 was not significantly different between the WB and IB groups in either the unadjusted analysis, or the analysis adjusted for calendar month of measurement, age, sex, and baseline BMI-for-age z score (Table 2).

Objectively Measured Physical Activity and Sedentary Time

Over 94% of the participants had valid accelerometer data (≥ 10 hours worn per day for ≥ 4 days including 1 weekend day) at each time point with no significant difference between groups. Mean time worn during the 17 hour window assessed was 16.5 hours with no significant difference between groups or between measurement periods.

Sedentary Time

Subjects in both groups averaged approximately 445 min/day of sedentary time assessed by the Actical accelerometer at baseline. There were no significant differences between the groups in sedentary time (Table 3) at baseline, week 6, or week 12. There were no significant changes in sedentary time in either group during the course of the intervention in either the unadjusted analysis, or the analysis adjusted for calendar month of measurement, age, sex, and baseline BMI-for-age z score (Table 3). Baseline sedentary time for children enrolling in the study tended to increase throughout the enrollment period (August to

January) with the lowest average sedentary time recorded in August (422 min/day) and the highest in January (458 min/day).

Physical Activity—Subjects in both groups averaged approximately 73 minutes of MVPA per day at baseline. There were no significant differences between the groups in the amount of MVPA (Table 4) at baseline, week 6 or week 12. While MVPA did decrease from baseline to week 6 in both the WB (−6.24 min/day, P = .059) and IB (−6.53 min/day, P = .047) groups in the unadjusted analysis, the decrease was no longer significant in the adjusted model (P = .577 and 0.446, respectively). There were no significant changes in MVPA in either group at week 12. There were no significant differences between groups in mean total activity (overall mean counts/minute) or mean intensity of MVPA (MVPA mean counts/minute). There were also no significant differences between groups in time spent in light, moderate, or vigorous intensity activity or in activity counts or mean intensity within these activity levels. Baseline MVPA for children enrolling in the study tended to decrease throughout the enrollment period (August to January), with the steepest decline beginning in November and continuing through January. Average baseline MVPA was 77 min/day for children enrolled before November first, and 68 min/day for those enrolled after November first.

We performed subgroup analyses to 1) examine the impact of the intervention in overweight children (BMI for age > 85 percentile, n = 10 in the IB group and n = 12 in the WB group) and 2) examine the impact of the intervention in children who were not meeting PA guidelines of > 60 minutes MVPA per day at baseline (n = 20 in the IB group and n = 22 in the WB group). There were no significant differences between the 2 intervention groups within either of the subgroup analyses, and there were no significant increases in MVPA in either subgroup.

Impact of Participant Weight Status

We divided subjects into overweight (BMI for age > 85 percentile, n = 22) and normal weight (BMI for age ≤ 85 percentile, n = 109) regardless of intervention group assignment to explore whether there was a differential impact of the AOM small changes intervention on MVPA or sedentary behavior in overweight versus normal weight children. There was no significant difference between overweight and normal weight children in baseline screen time as assessed by the sedentary behavior log (122 min/day vs. 124 min/day, P = .943), or in screen time reported at week 6 or 12. There were also no significant differences in change in screen time from baseline to week 6 or 12 in either overweight or normal weight children.

Baseline levels of sedentary time as measured by the Actical were significantly higher in the overweight group compared with the normal weight group (by ~29 min/day) and remained higher at all study time points (Table 5). There were no significant differences in change in sedentary time over the course of the intervention in either overweight or normal weight children in the unadjusted analyses or in the analyses adjusted for calendar month of measurement, age, and sex (Table 5).

Baseline levels of MVPA were significantly (P < .001) lower in the overweight group (by ~23 min/day) compared with the normal weight group and remained significantly lower at 6

($P < .001$) and 12 weeks ($P < .001$; Table 6). In the unadjusted analyses, there was a significant decrease in MVPA for normal weight children at week 6 ($P = .012$) and for overweight children at week 12 ($P = .010$); however, neither effect remained significant after adjusting for calendar month of measurement, age and sex ($P = .436$ and $P = .495$, respectively).

Discussion

Results of this study support the use of the internet to deliver lifestyle interventions in children. There were no significant differences between groups in sedentary time, screen time, or MVPA time at the end of the 12 week intervention, and no significant changes in these parameters over the course of the intervention in either group. Providing the AOM family intervention in an internet based format as compared with the traditional printed workbook format did not have a detrimental impact on either sedentary behavior or physical activity in overweight and normal weight children. Despite the fact that children's sedentary time might be expected to increase over the timeline that our study was performed (baseline measurements primarily in late summer/early fall and follow up measurements in late fall/winter) we observed no significant increase in sedentary time in the internet based group. Using the internet to deliver a small changes based intervention over a 12-week period in normal weight and overweight children did not increase screen time (watching television, using a computer, or playing videogames) as assessed by self-reported behavior logs or sedentary time objectively assessed with an accelerometer. Importantly, we observed that attrition rates were lower in the group assigned to the internet based intervention suggesting that this mode of delivery may be more engaging to children and families and could reduce attrition rates in a longer term study.

Although demonstrating an increase in physical activity was not the primary purpose of the study, we observed no significant change in average MVPA in either the WB or IB group during the course of the study. This is in contrast to our previous AOM family studies in which a significant increase in PA (assessed by pedometers) was seen.[10,11] However, we cannot conclude that the AOM intervention was ineffective without a concurrent control. It is possible that a control group would have demonstrated a significant reduction in PA during the course of the study compared with either the WB or IB groups. This is plausible given the current study was conducted between August 2010 and March 2011, with most participants enrolled by midfall and followed through midwinter. Children's activity levels have been shown to vary depending on season of measurement with lower levels of activity in the winter versus summer months.[21,25,26] We similarly observed decreasing baseline MVPA levels among those enrolling through the fall and winter months, and month of measurement was a strong predictor of MVPA in the adjusted models ($P < .0001$). The AOM program could have been attenuating this expected drop in activity. The statistical models partially accounted for this by including calendar month as a covariate in the adjusted models, but we could not fully adjust for the seasonal effects given there were no baseline measurements in February and March and no follow-up measurements in August and September.

There were several other differences between our current and former studies that may have limited the effectiveness of the intervention in increasing MVPA. Both prior studies targeted families with overweight children, while our current study targeted both normal weight and overweight children. In the current study, the average BMI-for-age was around the 50th percentile and our study subjects were already very active at baseline (~73 min/day MVPA, exceeding current physical activity guidelines for children of > 60 min/day most days of the week). However, subgroup analyses did not find a significant intervention effect in either overweight children (n = 22) or in participants recording less than 60 minutes per day of MVPA at baseline (n = 42). The step goal targeted in this study (an increase of 4000 steps/day) was higher than the step goal targeted in our prior AOM studies (an increase of 2000 steps/day). If the higher step goal used in the current study was not felt by participants to be attainable or realistic it is possible that the goal setting approach used in this study to increase steps may have been marginalized or ignored. Future research with the AOM Family intervention should evaluate the optimal step goal and goal setting strategy. The current study employed an objective measure of PA, while both of our prior AOM family studies, change in PA was assessed with self-reported measures (collecting pedometer logs in which participants self-recorded steps/day). Finally, the AOM family intervention may require some “in person” contact (as was included in our prior studies) to enhance receipt of the intervention and have a significant impact on level of physical activity.

Children who were overweight (BMI for age > 85th percentile) were significantly less active at all study time points than normal weight children. In addition children who were overweight (BMI for age > 85th percentile) had higher levels of sedentary time at all study time points. The inverse association between PA levels and BMI percentile in children in this study is consistent with previous findings.[29–31] We also found no significant differences in response to the intervention (ie, change in sedentary behavior or MVPA time) in normal weight as compared with overweight children in the analyses adjusted for calendar month of measurement, age and gender.

Strengths of our study include a randomized controlled design and use of objective measurements to assess sedentary time and physical activity. Limitations of our study include the fact that the variability in screen time and sedentary time was higher than anticipated in our sample size calculations. Given this, we cannot rule out difference between intervention groups of up to 21 min/day in sedentary time as assessed by the Actical (the upper limit for 95% confidence interval at week 12 was 20.86 minutes) and we cannot rule out a difference of up to 63 min/day in screen time as assessed by our sedentary behavior log (the upper limit for 95% confidence interval at week 12 was 63.13 minutes). In addition, our short term study was designed to evaluate the impact of an internet based intervention on sedentary behavior and was not designed or intended to evaluate the full impact of AOM message (ie, the longer term effect on parameters related to physical activity, energy intake and change in body weight). Actual time families spent receiving the intervention in either group, as well as data regarding workbook usage in the WB group (which could have been used to explore the extent to which the intervention was effectively delivered) was not collected as part of this study. Data from pedometer logs (which could have been used to explore whether children may have substituted steps for other activities) was also not collected. Finally, although subjects were required to reside in the primary study household > 50% of the time, we do not have data on how many participants were in split households.

Conclusions

Use of the internet to deliver a small changes based intervention over a 12-week period in children is a feasible strategy that does not appear to increase sedentary behavior or have a detrimental effect on physical activity in a group of normal weight and overweight children. An internet based intervention was also associated with lower attrition rates than the workbook based program over the 12-week intervention in this study. Based on the results of this short term study, we anticipate that providing the AOM Family intervention via an internet based format will improve subject retention and will not lead to increases in screen or sedentary time over a longer term period.

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Table 1

Baseline Characteristics for Target Children

	Workbook	Internet	*P*-value
Number of families	49	49	–
Number of target children	69	62	–
Number of children/family			
1	30	36	0.309
2	18	13	
3	1	0	
Age (years)	10.4 ± 1.4	10.5 ± 1.4	0.641
Gender (% male)	47.8	53.2	0.537
Race/ethnicity (%)			
White	68.1	75.8	0.398
African American	7.3	12.9	
Hispanic/Latino	10.1	6.5	
Asian	4.4	1.6	
More than 1 race	8.7	3.2	
Other/not reported	1.4	0.0	
Baseline measurements			
Weight (kg)	36.6 ± 9.4	37.4 ± 10.7	0.635
Height (cm)	142.1 ± 10.2	143.0 ± 10.3	0.613
BMI (kg/m^2)	17.9 ± 3.3	18.0 ± 3.3	0.890
BMI-for-age (z-score)	0.06 ± 1.1	0.10 ± 1.0	0.823
BMI-for-age (percentile)	50.8 ± 30.2	51.8 ± 28.8	0.848
Overweight (%)	17.4	16.1	0.847
Obese (%)	11.6	9.7	0.723

Note. Data presented as mean ± standard deviation or percentage of participants when indicated.

Table 2

Mixed Model Estimates[a] (95% CI) of Screen Time (Minutes/Day), Measured by the Sedentary Behavior Log, by Study Group

	Workbook	Internet	Difference	*P*-value
Weekly average[b]				
Baseline	136.96 (105.26, 168.65)	110.06 (80.37, 139.74)	−26.90 (−70.30, 16.50)	0.222
Week 6	133.52 (100.03, 167.00)	84.53 (53.18, 115.88)	−48.98 (−94.81, −3.16)	0.036
Week 12	122.66 (90.71, 154.60)	121.91 (90.76, 153.05)	−0.75 (−45.33, 43.83)	0.973
Change from baseline				
Week 6	−3.44 (−32.63, 25.75) *P* = .815	−25.52 (−46.13, −4.91) *P* = .016	−22.08 (−57.60, 13.43)	0.221
Week 12	−14.30 (−39.79, 11.19) *P* = .268	11.85 (−10.20, 33.90) *P* = .289	26.15 (−7.34, 59.63)	0.125
Adjusted change[c] from baseline				
Week 6	−7.50 (−40.69, 25.69) *P* = .656	−29.03 (−55.35, −2.72) *P* = .031	−21.53 (−57.51, 14.46)	0.239
Week 12	−17.16 (−57.15, 22.84) *P* = .399	12.34 (−24.58, 49.27) *P* = .511	29.50 (−4.14, 63.13)	0.085

[a]Random family effect included to account for multiple children per family. Kronecker (UN@CS) covariance structure used for repeated measures within an individual (3 time points × 2 measurements per time point). Covariance matrix estimated separately for each study group. Satterthwaite correction for denominator degrees of freedom.

[b]Average of 2 Sedentary Behavior Logs taken a week apart.

[c]Adjusted for calendar month, age, sex, and baseline BMI-for-age z score.

Table 3

Mixed Model Estimates[a] (95% CI) of Sedentary Time (Minutes/Day), Measured by Actical Physical Activity Monitors, by Study Group

	Workbook	Internet	Difference	*P*-value
Weekly average				
Baseline	447.29 (429.45, 465.13)	443.73 (426.55, 460.90)	−3.57 (−28.30, 21.17)	0.776
Week 6	462.23 (443.83, 480.62)	453.90 (435.80, 472.00)	−8.33 (−34.10, 17.44)	0.524
Week 12	460.70 (441.14, 480.26)	457.71 (440.01, 475.40)	−3.00 (−29.34, 23.34)	0.823
Change from baseline				
Week 6	14.93 (−1.18, 31.05) *P* = .069	10.17 (−4.92, 25.26) *P* = .184	−4.76 (−26.72, 17.19)	0.669
Week 12	13.41 (−3.26, 30.08) *P* = .114	13.98 (−0.52, 28.48) *P* = .059	0.57 (−21.39, 22.53)	0.959
Adjusted[b] change from baseline				
Week 6	6.20 (−11.06, 23.46) *P* = .479	−0.02 (−16.60, 16.55) *P* = .998	−6.22 (−27.01, 14.56)	0.556
Week 12	−2.80 (−25.80, 20.20) *P* = .811	−2.86 (−24.51, 18.79) *P* = .795	−0.06 (−20.98, 20.86)	0.996

[a]Random family effect included to account for multiple children per family. Kronecker (UN@CS) covariance structure used for repeated measures within an individual (3 time points × up to 6 daily measurements per time point). Covariance matrix estimated separately for each study group. Satterthwaite correction for denominator degrees of freedom.

[b]Adjusted for calendar month, age, sex, and baseline BMI-for-age z score.

Table 4

Mixed Model Estimates[a] (95% CI) of MVPA (Minutes/Day), Measured by Actical Physical Activity Monitors, by Study Group

	Workbook	Internet	Difference (95% CI)	*P*-value
Weekly average				
Baseline	72.45 (64.79, 80.10)	73.64 (66.01, 81.27)	1.19 (−9.60, 11.99)	0.827
Week 6	66.20 (58.66, 73.75)	67.11 (59.53, 74.70)	0.91 (−9.78, 11.60)	0.867
Week 12	68.47 (60.61, 76.34)	68.90 (61.04, 76.76)	0.43 (−10.68, 11.53)	0.939
Change from baseline				
Week 6	−6.24 (−12.73, 0.24) 0.059	−6.53 (−12.98, −0.08) 0.047	−0.29 (−9.37, 8.80)	0.951
Week 12	−3.97 (−9.80, 1.85) 0.179	−4.74 (−11.49, 2.00) 0.166	−0.77 (−9.63, 8.09)	0.865
Adjusted[b] change from baseline				
Week 6	−1.96 (−8.91, 4.98) *P* = .577	−2.43 (−8.72, 3.86) *P* = .446	−0.47 (−8.46, 7.52)	0.908
Week 12	3.44 (−5.34, 12.23) *P* = .441	1.81 (−6.99, 10.61) *P* = .685	−1.63 (−9.40, 6.14)	0.679

[a]Random family effect included to account for multiple children per family. Kronecker (UN@CS) covariance structure used for repeated measures within an individual (3 time points × up to 6 daily measurements per time point). Covariance matrix estimated separately for each study group. Satterthwaite correction for denominator degrees of freedom.

[b]Adjusted for calendar month, age, sex, and baseline BMI-for-age z score.

Table 5

Mixed Model Estimates[a] (95% CI) of Sedentary Time (Minutes/Day), Measured by Actical Physical Activity Monitors, by Baseline Overweight

	Overweight BMI > 85th percentile (n = 22)	Normal weight BMI ≤ 85th percentile (n = 109)	Difference	*P*-value
Weekly average				
Baseline	468.72 (442.28, 495.15)	439.99 (426.78, 453.20)	−28.72 (−56.83, −0.61)	0.045
Week 6	493.82 (466.41, 521.23)	450.07 (436.21, 463.92)	−43.75 (−73.10, −14.40)	0.004
Week 12	494.57 (467.23, 521.92)	451.43 (437.18, 465.67)	−43.14 (−72.63, −13.66)	0.005
Change from baseline				
Week 6	25.10 (−1.01, 51.21) *P* = .059	10.07 (−1.97, 22.12) *P* = .101	−15.03 (−43.59, 13.54)	0.296
Week 12	25.86 (−0.96, 52.67) *P* = .058	11.43 (−0.43, 23.30) *P* = .059	−14.42 (−43.53, 14.69)	0.324
Adjusted[b] change from baseline				
Week 6	17.85 (−8.29, 43.98) *P* = .180	−0.28 (−14.26, 13.70) *P* = .969	−18.13 (−45.57, 9.32)	0.194
Week 12	7.21 (−22.88, 37.30) *P* = .638	−5.91 (−25.85, 14.04) *P* = .560	−13.12 (−40.55, 14.32)	0.347

[a]Random family effect included to account for multiple children per family. Kronecker (UN@CS) covariance structure used for repeated measures within an individual (3 time points × up to 6 daily measurements per time point). Satterthwaite correction for denominator degrees of freedom.

[b]Adjusted for calendar month, age, and sex.

Table 6

Mixed Model Estimates[a] (95% CI) of MVPA (Minutes/Day), Measured by Actical Physical Activity Monitors, by Baseline Overweight

	Overweight BMI > 85th percentile (n = 22)	Normal weight BMI ≤ 85th percentile (n = 109)	Difference	*P*-value
Weekly average				
Baseline	54.01 (43.80, 64.21)	77.47 (71.94, 83.01)	23.47 (12.60, 34.33)	<0.001
Week 6	46.55 (36.05, 57.06)	71.18 (65.76, 76.59)	24.62 (13.52, 35.73)	<0.001
Week 12	41.75 (31.71, 51.80)	74.50 (68.79, 80.21)	32.75 (21.92, 43.58)	<0.001
Change from baseline				
Week 6	−7.45 (−17.69, 2.78) *P* = .147	−6.30 (−11.19, −1.40) *P* = .012	1.16 (−10.09, 12.40)	0.837
Week 12	−12.25 (−21.27, −3.24) *P* = .010	−2.97 (−7.79, 1.85) *P* = .225	9.28 (−0.83, 19.40)	0.071
Adjusted[b] change from baseline				
Week 6	−2.45 (−12.43, 7.53) *P* = .629	−2.16 (−7.59, 3.28) *P* = .436	0.29 (−10.13, 10.71)	0.956
Week 12	−4.00 (−15.51, 7.51) *P* = .495	3.68 (−4.15, 11.51) *P* = .356	7.67 (−2.56, 17.91)	0.141

[a] Random family effect included to account for multiple children per family. Kronecker (UN@CS) covariance structure used for repeated measures within an individual (3 time points × up to 6 daily measurements per time point). Satterthwaite correction for denominator degrees of freedom.

[b] Adjusted for calendar month, age, and sex.