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Step Tracking with Goals Increases Children's Weight Loss in Behavioral Intervention

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Abstract

Background: This study examined the influence of step goals with pedometers to improve children's weight loss, physical activity, and psychosocial health during obesity treatment.

Methods: Overweight and obese children ages 8–17 years ($n = 105$) participated in a 10-week family-based weight management intervention, including physical activity, nutrition, and behavioral modification. A quasi-experimental design was used to group eight cohorts into three conditions: no pedometer ($n = 24$), pedometer only ($n = 25$), and pedometer with step goals (*i.e.*, 500 steps/day weekly increase above baseline; $n = 56$). Height and weight were measured at baseline and week 10 and used to calculate BMI. Analysis of covariance was performed to examine difference by condition for change in weight, BMI, and BMI z-score, controlling for age and baseline value. Differences in steps per day and psychosocial health were compared between the two pedometer conditions.

Results: Participants were 12.4 ± 2.5 years of age, including 70% girls and 64% African Americans. The pedometer with goals condition significantly reduced BMI ($p = 0.02$) and BMI z-score ($p = 0.01$) compared with the no-pedometer group. The pedometer with goals condition significantly increased steps per day ($+1185 \pm 425$ steps/day) compared with the pedometer-only condition (-162 ± 620 steps/day; $p < 0.05$). Both pedometer groups similarly increased in subjective health and quality of life.

Conclusions: Providing children with pedometers and individualized step goals was an effective approach to produce weight loss. Further work is needed to increase the strength of interventions to achieve clinically meaningful weight reduction for children with obesity.

Keywords: behavior goals; pedometer; physical activity; obesity; self-monitoring

Introduction

Obesity affects 17% of children and adolescents in the United States.[1] Insufficient levels of physical activity are related to obesity,[2] and youth with obesity spend significantly less time each day in moderate-to-vigorous physical activity compared with their normal-weight peers.[3] Physical activity counseling has been identified as a critical component of weight management in children by several organizations, including the American Medical Association,[4] the US Preventive Services Task Force,[5] and healthcare professionals.[6] The identification of tools and strategies to effectively increase physical activity within pediatric weight-loss programs is a research priority.[7]

Wearable activity trackers like pedometers are inexpensive, objective ways for children to self-monitor physical activity, and are suggested as a way to increase children's awareness and regulation of their physical activity.[6] In adults, a recent systematic review indicated that behavioral physical activity interventions that include an activity monitor increased physical activity levels, but there was inconclusive evidence that activity monitors affect weight loss.[8] For instance, a 12-week physical activity and dietary counseling intervention observed significantly more weight loss among adults who received a pedometer vs. those who did not,[9] whereas a 2-year randomized controlled trial observed no beneficial effect of integrating pedometers into a comprehensive weight management program for adults.[10]

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Similarly, in children and adolescents, the addition of pedometers to interventions has demonstrated moderately increased physical activity, but findings are equivocal for weight loss. The addition of pedometers to physical activity and weight management programs has increased children's physical activity by 1000–3000 steps per day above baseline.[11–14] A 12-week study targeting adolescents with type 1 diabetes observed no significant change in physical activity in a group who received a pedometer with motivational text messages vs. a control group.[15] Additionally, there are few data available on the influence of pedometers on children's weight loss. A 12-week study, where children were provided with pedometers and a standard daily step goal, indicated no difference in BMI percentile change from a control condition.[16]

Despite a lack of effectiveness data, family-based weight management programs are using pedometers to help children track their physical activity. A recent survey on pediatric weight management programs from 25 children's hospitals indicated that all programs included physical activity counseling and the majority (82%) used an objective measurement of physical activity, including 22% that used pedometers.[6] A missing component of prior pedometer-based weight management trials is integrating behavior change strategies in conjunction with the activity tracker. For instance, the use of pedometer-specific goals may motivate children's physical activity. Self-monitoring and learning to self-regulate behaviors are mechanisms for weight loss,[17] and providing physical activity goals that gradually increase in difficulty has been suggested as a way to increase children's motivation for behavior change.[6]

The primary purpose of the study was to examine the influence of pedometers with step goals to improve children's weight loss during behavioral treatment. Secondary aims were to examine the effects of pedometers with step goals on the children's physical activity and psychosocial health.

Methods

Participants

The participants included 105 children recruited over eight cohorts. Eligibility criteria included children ages 8–17 years old with BMI ≥95th percentile or a BMI ≥85th percentile with comorbidities, such as fatty liver disease, hypertension, heart disease, insulin resistance, orthopedic problems, sleep apnea, or type 2 diabetes. Community physicians referred eligible participants to the Obesity Clinic at the Our Lady of the Lake Children's Hospital. During a clinic visit with a pediatric gastroenterologist or dietitian, patients and their parents underwent an initial evaluation with complete history and physical examination, dietary evaluation, laboratory studies, determination of program readiness, and assurance of family commitment. Once admitted to the intervention, parents and children provided informed consent and assent, respectively (verbal assent if child was between 8 and 11 years of age, written assent if child was 12 years or older). The Institutional Review Boards of the Our Lady of the Lake Children's Hospital and the Pennington Biomedical Research Center approved all study procedures. The trial was registered at Clinicaltrials.gov number NCT02965729.

Behavioral Intervention

The ''Our Lifestyles, Our Lives'' weight management intervention consisted of a series of 10 weekly 90-minute group sessions focused on physical activity, nutrition, and behavioral modification. For each cohort, eight sessions were taught in the Translational Research Clinic for Children at Pennington Biomedical Research Center, one session was held at a local grocery store, and one session was held at a quick service restaurant. Parents and siblings were encouraged to join the participant during each session. Sessions were taught by a multidisciplinary staff, including a pediatric gastroenterologist, pediatricians, clinical psychologist, dietitian, and kinesiology-trained fitness specialists. Sessions were interactive and included cooking demonstrations, light-to-moderate intensity physical activity that engaged all family members and behavioral counseling sessions in both mixed (parent and child) and parent-only format. The program aligned with the American Medical Association expert committee recommendations for stage three of treatment for childhood obesity consisting of comprehensive multidisciplinary intervention.[4] A synopsis of the curriculum is displayed in Table 1.

Participants received a 72-page program guide, including weekly goal sheets and handouts with healthy recipes. The weekly goal sheet was completed by the family and included a prescribed nutrition goal, tracking of daily water consumption, minute-goals for physical activity, pedometer target step goals (cohorts 3–6 only), and space to write in self-selected behavioral goals. Families used the goal sheet to track goal achievement throughout each week.

Participants received small incentive items of negligible value (*e.g.*, bouncing ball, jump rope, water bottle, and nail polish) throughout the program to reward and encourage participation, compliance, attendance, and achievement of program goals. Each participant received a $25 gift card at the grocery store session (session 9) and a $25 gift card at the final session (session 10).

Conditions. Eight cohorts of between 8 and 19 participants sequentially attended the program over the course of 2 years. Cohorts were grouped into three conditions: no pedometer (NP; $n=24$), pedometer only (P; $n=25$), or pedometer with individualized step goals (PG; *i.e.*, 500 steps/day increase each week above baseline, $n=56$). Cohorts were scheduled throughout the year to control for seasonal effects between PG vs. NP and P, such that NP occurred in summer and fall, P occurred in winter and spring, and PG occurred in each of the four seasons. Participants in cohorts 1 and 2 did not receive a pedometer. In cohorts 3–8, participants were given a pedometer and

Table 1. Standardized Curriculum of the 10-Week Behavioral Intervention for Childhood Obesity

Session	Location	Physical activity lesson	Nutrition lesson	Behavior modification
Session 1	TReCC			Steps to goal setting
Session 2	TReCC	Introduction to barriers	Let's talk sugar	
Session 3	TReCC	I don't know what to do	My plate & lunch in a crunch	Rules for eating
Session 4	TReCC	It's raining, it's too hot	Cutting back the fat	
Session 5	TReCC	I don't have money	Hurray for whole grains	10 Tips for parents
Session 6	Quick serve restaurant	I have other stuff to do	Eating healthy while on the go	
Session 7	TReCC	I'm too tired, it's boring, it's too hard	Fruits and veggies	ABCs of behavior
Session 8	TReCC	I don't have time, it's raining, it's too hot	Portion control & energy balance	
Session 9	Grocery store		Grocery store scavenger hunt	
Session 10	TReCC	Challenge your barriers & 1 mile walk/run	Motivation and review	Individual check-in with parents/review

ABCs, antecedents, behaviors, consequences; TReCC, Translational Research Clinic for Children.

instructions at session 1. Participants were asked to wear the pedometer every day for the entirety of the program and return it at session 10. In cohorts 3–6, participants were given a step goal to increase their activity by 500 steps per day each week (above baseline calculated as average daily steps/day during week 1), for a total of 4500 steps per day increase by the end of the program. In cohorts 7 and 8, participants were given the pedometer, but no step goals.

Measurements

Body weight, height, and BMI. Height was measured at session 1 (baseline) and session 10 using a wall-mounted stadiometer. Weight was measured at the beginning of each session using a calibrated scale (excluding off-site sessions 6 and 9).

Pedometer. The pedometer provided to the P and PG conditions was the Omron HJ-324U, Omron Healthcare, Lake Forest, IL (cost between $30–40 each). In cohorts 3–8 (the PG and P conditions), the physical activity data, including daily steps, were downloaded from the pedometer through USB and/or manually during weekly sessions; therefore, physical activity during the session was not captured.

Psychosocial questionnaire. A pre- and posttest psychosocial questionnaire was completed by each participant at the beginning (session 1) and end (session 10) of the program. The questionnaire included the following validated instruments: the KIDSCREEN-10 Index to assess quality of life[18]; a single Likert scale assessment of subjective health (''In general, how would you say your health is?'')[19]; and the Physical Activity Enjoyment Scale, a 16-item measure of enjoyment during physical activity.[20]

Statistical Analysis

Twenty-one participants did not attend the last two clinic sessions so they did not provide a final weight (7 in NP condition, 3 in P condition, and 11 in PG condition), leaving an analytical sample size of 84. Nearest height and weight within 2 weeks were imputed for those missing week 0 and week 10 values, and baseline height was imputed for 28 participants missing week 10 height. BMI z-score was calculated from the CDC SAS macro program based on the sex, height, and age of the child.[21] Of the 81 participants in the P and PG conditions, 16 were missing all step data due to damaged, lost, forgotten, or malfunctioning pedometer. Of the 65 participants with step data, 83% of data were complete. The missing data were due to absences or device malfunction. See Figure 1 for the flow of participants through the intervention.

The primary endpoints of the program were change in body weight, BMI, and BMI z-score. Secondary endpoints were change in physical activity (average weekly steps), physical activity enjoyment, subjective health, and health-related quality of life. Difference scores were calculated between initial and final assessment. Analysis of covariance models was calculated to examine change in each primary endpoint, with condition as the independent variable and age and baseline value as covariates. *Post hoc* Tukey's tests were used to examine differences between conditions. In secondary models, the covariates of sex, race, and attendance were added. Paired samples *t*-tests were used to examine change in psychosocial variables

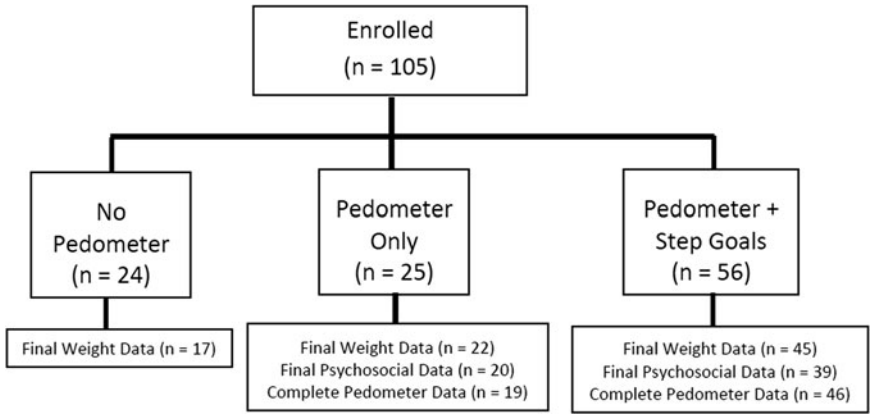

Figure 1. Flow diagram of participants through the intervention.

collapsed across the conditions. Paired samples *t*-tests were used to examine change in daily steps from baseline for the PG and P conditions. In addition, independent samples *t*-tests were used to compare daily steps each week between the two conditions.

Results

There were a total of 105 participants. Participants were on average 12 ± 2.5 years of age, and the sample included 70% girls and 64% African Americans, 31% Caucasians, and 5% other races. The majority (65%) were insured by Medicaid, with the remaining on private insurance. There was no significant difference by condition in baseline BMI z-score or BMI percentile or by sex, race, or insurance status. The PG group was older ($p = 0.01$) and had a significantly higher weight ($p = 0.02$) and BMI ($p = 0.03$) compared with the other groups; therefore, age and baseline value were included as covariates in all analyses. There was no difference between those who did and did not provide a final weight for age, sex, race, insurance status, or baseline weight, BMI, BMI z-score, or BMI percentile. See Table 2 for baseline characteristics overall and by condition.

Table 2. Baseline Descriptive Characteristics of the Sample

	No pedometer ($n = 24$)	Pedometer only ($n = 25$)	Pedometer + step goals ($n = 56$)	Overall ($n = 105$)
Age, years	11.4 ± 2.5	11.7 ± 2.1	13.1 ± 2.6	12.4 ± 2.5
Girls, %	75	64	70	70
Race, %				
African American	54	64	68	64
White	38	28	30	31
Other	8	8	2	5
Weight, kg	73.0 ± 22.9	86.2 ± 24.8	90.1 ± 24.0	85.3 ± 24.7
BMI, kg/m^2	32.2 ± 7.3	35.2 ± 6.4	36.1 ± 5.7	35.0 ± 6.4
BMI, z-score	2.3 ± 0.4	2.5 ± 0.3	2.4 ± 0.3	2.4 ± 0.3
BMI, percentile	98.4 ± 1.7	99.2 ± 0.7	99.0 ± 1.3	98.9 ± 1.3
Steps/day	—	4889 ± 1492	4376 ± 2188	4487 ± 2048
Physical activity enjoyment[a]	—	66.1 ± 8.6	60.8 ± 12.5	62.4 ± 11.7
Subjective health[a]	—	3.1 ± 1.1	3.3 ± 1.0	3.3 ± 1.1
Quality of life[a]	—	39.0 ± 6.2	38.4 ± 7.1	38.6 ± 6.8

Data are reported as mean ± standard deviation.

[a]Data were not collected for the "No-Pedometer" cohorts and data were missing for 3 Pedometer-Only participants and 17 Pedometer + Step Goals participants.

Table 3. Absolute Change in Weight-Related Parameters after 10 Weeks

	No pedometer ($n = 17$)	Pedometer only ($n = 22$)		Pedometer + step goals ($n = 45$)	
	Mean ± SD	Mean ± SD	*p*	Mean ± SD	*p*
Body weight (kg)	1.12 ± 1.90	0.23 ± 1.87	0.522	−0.49 ± 2.06	0.045
BMI (kg/m^2)	0.43 ± 0.82	−0.24 ± 0.78	0.087	−0.37 ± 0.92	0.017
BMI (z-score)	0.01 ± 0.04	−0.03 ± 0.04	0.098	−0.03 ± 0.05	0.012

p-Values are compared with the No-Pedometer group in analysis of covariance models controlling for baseline age and baseline variable (weight, BMI, or BMI z-score).

SD, standard deviation.

Four participants (4%) only attended the first session and were lost to follow-up; therefore, they were not included in the analyses. Excluding these dropouts, attendance averaged 74% (*i.e.*, 7.4 of 10 sessions) and did not vary by condition.

Body Mass

Overall, the mean weight change was +0.02 kg, the mean BMI change was −0.20, and the mean BMI z-score change was −0.02. As indicated in Table 3, there was a significant difference by condition in change in weight, BMI, and BMI z-score ($p < 0.05$). *Post hoc* Tukey's tests indicated that the PG condition had a significantly greater reduction in weight ($p = 0.045$), BMI ($p = 0.017$), and BMI z-score ($p = 0.012$), compared with the NP condition. When included as covariates, race, sex, and attendance did not attenuate the observed effects.

Physical Activity

Average change in daily steps compared with baseline was 1185 ± 425 daily steps for the PG condition vs. −162 ± 620 daily steps for the P condition. Compared with baseline daily steps, the PG condition had significantly higher daily steps at every week after the goals were implemented (week 3: $p < 0.001$, week 4: $p < 0.001$, week 5: $p < 0.001$, week 6: $p < 0.001$, week 7: $p = 0.01$, week 8: $p = 0.001$, week 9: $p = 0.04$). The P condition did not vary in steps from baseline values at any week. Compared with the P condition, the PG condition accumulated significantly more daily steps at week 3 ($p = 0.006$), week 6 ($p = 0.005$), week 7 ($p = 0.005$), and week 8 ($p = 0.03$), but differences at the other weeks were not significant (Figure 2).

Psychosocial Health

With the two pedometer groups combined, there was a significant increase in subjective health ($p < 0.0001$) and health-related quality of life ($p < 0.01$), but no change in physical activity enjoyment (Table 4). There were no differences between the P and PG conditions for change in physical activity enjoyment, subjective health, or health-related quality of life.

Discussion

This study investigated the additive benefit of adding pedometers plus step goals to a family-based weight

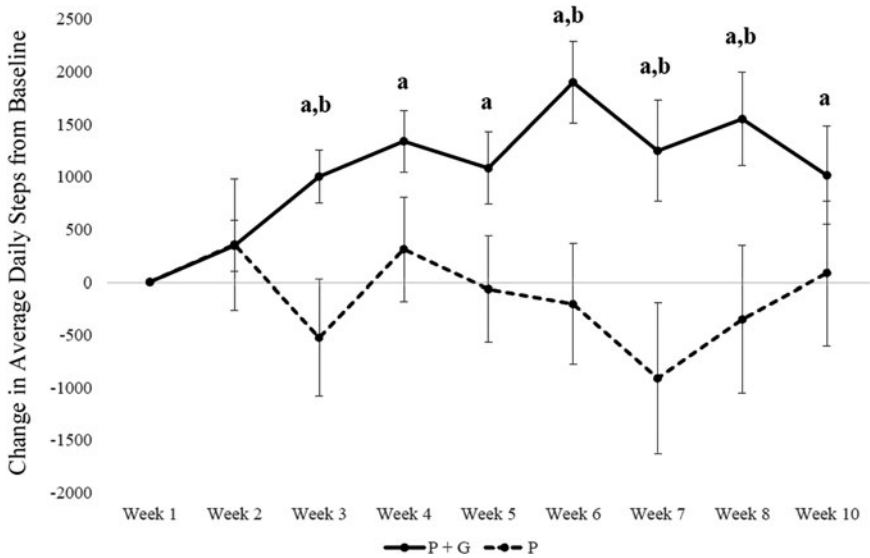

Figure 2. Change in pedometer-measured steps from baseline. Error bars indicate standard error. [a]Indicates a significant differences from baseline using paired samples t-test. [b]Indicates a significant difference between conditions using independent samples t-test.

Table 4. Absolute Changes in Psychosocial Factors after 10 Weeks

	Pedometer only ($n = 20$) Mean ± SD	Pedometer + step goals ($n = 39$) Mean ± SD	p
Physical activity enjoyment	0.02 ± 8.25	2.66 ± 10.90	0.175
Subjective health	0.55 ± 1.34	0.66 ± 1.00	0.083
Health-related quality of life	2.2 ± 4.5	0.9 ± 5.3	0.343

p-Values are obtained from analysis of covariance models controlling for baseline age and baseline psychosocial variable. Data were not assessed in the No-Pedometer group.

management intervention to increase weight loss, increase physical activity, and improve psychosocial health among children and adolescents. Children showed high adherence to wearing the pedometer, with 83% of the pedometer data being complete, indicating the feasibility of using pedometers in a structured weight management program. Given the recent proliferation of wearable technology,[22] wearable devices are expected to be attractive to children and families.

Children who received the pedometers and individualized step goals reduced weight and BMI z-score to a greater extent than children who did not receive a pedometer or step goals. Over the 10-week period, total weight loss in the pedometer and goals group (–0.49 kg) was similar to the amount observed in a meta-analysis ($\sim$0.05 kg/week) of nine pedometer-based walking studies in adult cohorts.[23] However, when converted to z-score, the weight loss did not meet criteria for clinically meaningful loss of at least 0.25 z-score reduction.[24,25] Therefore, a longer duration behavioral intervention that meets or exceeds current recommendations[5] is recommended for clinically meaningful weight reduction.

The secondary aim was to examine the effect of the pedometer plus goals on youths' physical activity levels and psychosocial health. The pedometer plus goals condition significantly increased daily steps by an average of 1185 steps per day, whereas the condition that received only the pedometer without step goals did not change steps from baseline. When using pedometers to measure physical activity, a total of 9000 steps per day is recommended for children and adolescents to reach 60 minutes of moderate-to-vigorous physical activity.[26] At baseline, participants accumulated only one-half of the recommended number of steps per day.[26] By the end of the intervention, the children were closer to 65% of recommended daily steps, but did not meet the study-specific physical activity goals of an overall 4500 steps per day increase. The increase of 1185 steps per day is similar to one pediatric trial that observed $\sim$1000 steps per day increase over 9 months using pedometers and structured outdoor activities,[12] but lower than other pediatric trials that achieved between 1500 and 3000 steps per day increase above baseline.[11,13,14,27] The latter studies taught additional behavior change strategies such as coping skills training[11] and behavior modification skills for parents.[27] Therefore, the use of additional behavior change strategies beyond individualized step goals may be needed to increase children's physical activity to recommended levels. Additional recommendations to increase children's physical activity include enhanced physical education, classroom activity breaks, developing behavioral skills to increase children's confidence related to physical activity, and replacing inactivity with activity, such as walking or bicycling to school and engaging in physical activity during screen time.[28]

Both pedometer groups significantly improved in subjective health and health-related quality of life, without a difference between the two groups. These findings build on a prior study that observed a nonsignificant trend in higher quality of life for children aged 6–12 years who were randomized to a pedometer-based intervention with structured weekend outdoor activities vs. a control group.[12] Future studies should examine the specific interventional elements that improve quality of life, such as self-esteem or self-efficacy improvements from using a pedometer to self-regulate physical activity or the other behavior change strategies that were taught in the weight management program. Health-related quality of life is identified as an important outcome of obesity intervention research by the NIH[29] and as a key measure of population health in the Healthy People 2020 report.[30] Because youth with obesity are at risk for low quality of life related to both physical health and psychosocial health,[31] it is important to identify interventions such as the present one that improve health-related quality of life among children and adolescents.[32]

Strengths of this study include the use of objective measurements of physical activity and weight, as well as a focus on a population at high risk for obesity and associated comorbidities, with the sample being majority African American and insured by Medicaid.

There are several limitations to this study. The quasi-experimental design prevented the use of randomization, and there were baseline differences between conditions that were corrected using covariates in the analyses. Although the program remained consistent in intervention delivery, there may have been variation across seasons and time due to the sequential nature of the conditions. Seasonal effects have been observed for children's physical activity;[33] this limitation was addressed by holding the pedometer plus goals condition across one full year (each of four cohorts occurred during each season). Participants were recruited from several pediatric clinics, but streamlined through one pediatric gastroenterology clinic which determined a family's readiness to participate in the program, thereby limiting generalizability. Psychosocial surveys were not added until the third cohort, so there are no data for the no-pedometer group. Future research should involve randomized controlled trials with larger samples to

isolate the effects of specific tools and strategies to effectively promote physical activity and weight loss among children and adolescents.

Conclusion and Clinical Implications

Pedometers are low-cost devices that are popular among consumers and can be integrated into clinical settings to help children self-regulate their physical activity.[6] The addition of a pedometer coupled with step goals based on baseline values increased both physical activity and weight loss in children participating in a family-based behavioral treatment program for weight management. However, the pedometer alone without step goals was not sufficient to significantly impact weight or physical activity. Identifying adjuncts to in-person treatment of childhood obesity coupled with behavior change strategies remains a priority to achieve clinically meaningful weight loss and behavior change in children and adolescents.

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Author Disclosure Statement

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