LAST: LEISURE ACTIVITY STEP TRACKING STUDY

by

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Introduction

Type 2 Diabetes (T2DM) is currently the seventh leading cause of death in the United States [1]. Furthermore, nearly 86 million U.S adults have prediabetes [1]. One of the cornerstones for T2DM management is physical activity. The CDC recommends 150 minutes of moderate-intensity aerobic activity every week [5]. . Physical activity has been shown to be an effective method for management of many chronic diseases, including T2DM [6]. Physical activity is a component of T2DM management and prevention because increased physical activity levels can reduce many risk factors associated with T2DM including metabolic syndrome. Metabolic syndrome is a group of conditions including increase blood pressure, high blood glucose, and increased hip-to-waist ratio. These are all signs that increase risk of developing heart disease, stroke, and T2DM. With increased physical activity these risk factors can all be reduced.

However, increasing physical activity means more than traditional forms of exercise (e.g., gym). In fact, in November of 2018, the U.S Department of Health and Human Services produced updated guidelines for physical activity, which included the removal of the bout length requirement previously stated. These physical activity guidelines can be achieved by increasing participation in leisure-time physical activity, as nation surveys reveal estimates between 22% and 30% of adults report no participation in leisure time physical activity [2]. Leisure time physical activity can include- walking at lunch time, taking the stairs at work, gardening, parking further from destination, etc.

Tracking this form of physical activity may best be recorded by utilizing wearable technology. Research has demonstrated the importance of goal setting to increase intentional physical activity to reach the CDC recommendation of 150 minutes per week, but there is a gap when it comes to utilizing leisure time physical activity as a way of reducing T2DM. Most studies, such as the CDC's Diabetes Prevention Program (DPP), are aimed at discovering whether modest weight loss through dietary changes and increased physical activity could prevent or delay the onset of type 2 diabetes in study participants [9]. For example, the DPP had a lifestyle intervention group that received intensive training in diet, physical activity, and behavior modification. By eating less fat and fewer calories and exercising for a total of 150 minutes a week, they aimed to lose 7 percent of their body weight and maintain that loss over one year [9]. These programs often have one aim for everyone in the study, and therefore lack personal, tailored adaptive goals that allow each participant to be successful.

When similar programs are implemented in a community setting, they are found to be effective initially, over the intervention period, but there is little to no follow up in the post-intervention period. For example, a study of four diabetes intervention program sites in Montana was conducted, which found that Ninety-seven percent of participants lost weight (285 of 293). Forty-five percent of the participants (133 of 293) achieved the 7% weight loss goal, and 67% (195 of 293) achieved at least 5% weight loss, but nowhere in their findings was there mention if any participants regained the weight they loss of if it was maintained [10]. To address how these lifestyle interventions can be maintained for long-term it is important to consider some of the motivational factors that affect lifestyle change, such increased effort by the community and healthcare providers to encourage and incentivize physical activity in patients [11] who may use

lack of time, and access to fitness facilities [12] as reasons for not making and maintaining healthy life style changes.

Increasing leisure time physical activity can be achieved through setting a personalized adaptive steps-per-day goal [3]. Wearable technology that allows participants track steps-per-day is an increasing trend, and although some may be hesitant at first to utilize one, when subjects with chronic medical conditions are given free trackers they are motivated to increase physical activity behaviors regardless of their initial attitudes [4]. These trackers are widely available, and can be utilized as an education tool to promote self-efficacy in commitment to increase physical activity because they provide immediate feedback on step-count and progress toward daily goal [4]. The most important aspect of intervention for diabetes, is maintaining these new habits long-term, creating a lifestyle intervention. Short term studies have been conducted and prove that personalized step goals help individuals increase and maintain changes in physical activity [3]. Yet more studies need to be conducted to see if increased physical activity levels are maintained after participation in an intervention program [3].

Methods

The *Leisure Activity Step Tracking (*LAST) research study was a pilot, exploratory intervention utilizing leisure activity step tracking to decrease risk factors associated with Type 2 Diabetes Mellitus. The LAST)study was conducted between August 2019 and November 2019. The research protocol was reviewed and approved by the Institutional review Board of East Carolina University.

Participants

Participants were recruited in the Greenville, NC area through various email outlets. Research incentive included a 4-week exercise guide created by an American Council on Exercise certified personal trainer. There were a total of 3 participants. Inclusion criteria consisted of the following: between the ages of 18-65 years old, currently physically inactive (classified as <150 minutes of moderate intensity physical activity per week), already diagnosed with T2DM, have mobile device that can connect to a Fitbit and download the Fitbit app, and be able to meet for one hour meetings once a week for 6 weeks.

Intervention

All participants participated in two consecutive 6-week phases of the study, an active and inactive phase. During the 6-week active phase, there was one-hour group meetings once a week with all participants and the research facilitator. During these weekly meetings, participants would calculate their average steps per day utilizing the data stored on the Fitbit app. Each participant had their own Fitbit and Fitbit account which only they and the research team had access to see the data. Based on a 10% increase of the previous weeks average, each participant set an individualized step goal for the upcoming week. (i.e: week 1 average of 2,000 steps per day resulted in a week 2 step goal of 2,200 steps per day) This step goal was evaluated and reset each week for 6 weeks. These weekly meetings also included discussion and education on topics related to behavior change (i.e: motivation, barriers, benefits of PA, etc.). Each topic had a corresponding presentation delivered by the research facilitator and accompanying worksheets in a participant guide. Each participant received their own copy of the guide. These meetings, also included some form of leisure time physical activity, such as a walk, chair stretching or standing exercises. Lastly, each week participants completed surveys to evaluate: motivation, barriers and adherence. Following the meeting, participants were asked to respond in a private LAST Facebook group to a discussion prompt.

Following the conclusion of the 6-week active phase, came the 6-week inactive phase. During this time, there was no longer any in person group meetings. Participants were asked to continue to where their Fitbits. Every Tuesday they were emailed a link to complete a Qualtrics survey, which asked them to submit their steps for the previous 7 days. They also continued to completed surveys to evaluate: motivation, barriers, and adherence.

Measurements

The study consisted of 3 assessments, one prior the start of the 12-week study (time 0), one after completion of week 6 (time 1), and one after the completion of week 12 (time 2). Assessments and data collection were conducted by the principal investigator. All participants (n = 3) gave written informed consent to participate in the study. All participants completed an online Qualtrics survey that gathered quantitative information using the following methods

a. Demographic: Demographic information was collected through a Demographic Survey. This assessed age, education, race, ethnicity, sex and household income.
b. PA History: PA history was evaluated using the PA history questionnaire. This questionnaire addressed a physical constraint. This questionnaire quantifies the length since being physically active and reasons why PA was stopped.
c. Motivation: Motivation was evaluated using the RM 4–FM: Motivation for Physical Activity and Exercise/ Working Out—Questionnaire. This questionnaire addressed a mental constraint by evaluating intrinsic vs extrinsic motivation
d. Barriers to PA: Barriers to PA was evaluated using the 8 Road to health barriers quiz. This quiz addressed a mental constraint, and measured reasons why one does not participant in PA.
e. Processes of Change: The Processes of change was evaluated using the Processes of change questionnaire. This questionnaire evaluated a mental constraint while measuring the incorporation of PA in everyday life.
f. Physical Benefits of PA: The physical benefits of PA were evaluated using the Decision of Balance & Activity of Daily Living Questionnaire. This questionnaire evaluated a physical constraint and measured changes in physical fitness.
g. Mental Health Benefits of PA: The mental health benefits of PA was evaluated using the Hospital Anxiety and Depression Scale (HADS). This scaled addressed a mental constraint and evaluated changes in mood.
h. Perceived Stress: Perceived stress was evaluated using the Perceived stress scale Questionnaire. This questionnaire measured a mental constraint and evaluated participants perceived stress in their life.
i. Satisfaction with Life: Participant satisfaction with life was evaluated using a 5-item satisfaction with life scale questionnaire. This questionnaire evaluated a mental constraint and measured fulfillment of life.
j. Confidence: Confidence was evaluated using a self-efficacy questionnaire. This questionnaire addressed mental constraints and was used to evaluate participants belief in their own ability to make change.
k. Outcome Expectations of PA: Outcome expectations of PA was evaluated using the Outcome Expectations for exercise questionnaire. This questionnaire evaluated a mental constraint and measured the expectations participants had of PA.
l. PA Enjoyment: PA enjoyment was evaluated using the PA enjoyment scale. This scale evaluated a mental constraint utilizing statements in which participants rated how they felt about PA. On one end of the scale was a positive statement and the opposite was a negative.

Additionally, anthropometric data was collected for all participants. These measures were specifically chosen because the higher their values correlates with greater risk of developing metabolic diseases such as type two diabetes. Circumference measures and blood pressure were each taken three times per visit in order to formulate a more accurate average and account for

slight variability in measurements. Measurements were all taken by a trained research facilitator. The measurements include the following:

a) height and weight to calculate body mass index: Height was recording a stadiometer with participants shoes off, and was recorded in centimeters (cm). Weight was recorded in kilograms and was taken with participants shoes off. Body mass was calculated by dividing weight in kilograms by height in meters squared. This is equal to kg/m2.
b) Natural waist circumference: Natural waist was measured using a Gulick tape around the bra line and was recorded in cm.
c) Umbilical waist circumference: Umbilical waist was measured using a Gulick tape around the belly button and was recorded in cm.
d) Hip circumference: Hip circumference was measured using a Gulick tape around the hip bones and was recorded in cm.
e) Blood pressure: Blood pressure was taken with participants sitting down, utilizing a manual sphygmomanometer cuff which was inflated to 180 mmHg.

Results

Participants

The sample population consisted of 3 females with the following demographics: The average age of subjects was 57 ± 2.8 years. The race of subjects was 100% White. Education level of subjects 66% had a Master's Degree, and 33% had a Bachelor's Degree. The ethnicity was 33% Hispanic and 66% non-Hispanic, Spanish or Latino. The annual household income level of subjects featured 33% earning $40,000 to $49,999, 33% earing $100,000 to $149,999, and 33% earing $150,000 or more.

Anthropometric *Assessments*

Anthropometric assessments included Body Mass Index (BMI), blood pressure, natural waist, umbilical waist, and hip measurements. These measurements can be related back to risk factors associated with type 2 diabetes. Averages of these measurements where taken at time 0, 1, and 2 for each participant. The overall average for participants was calculated in SPSS. Percent change analysis was completed using excel. A positive percent change, represents an increase in the average and a negative percent change represents a decrease in the average.

Anthropometric Assessments Averages

Measurement	Time 0	Time 1	Time 2
BMI	35	35	35
Systolic Blood pressure	111	91	92
Diastolic blood pressure	75	76	76
Natural waist (cm)	102	104	107
Umbilical waist (cm)	114	117	116
Hip (cm)	121	121	119

Antrhopometric Assessments Percent Change

Measurement	Time 0 to 1	Time 1 to 2	Time 0 to 2
BMI	0%	0%	0%
Systolic Blood pressure	-17%	1%	-17%
Diastolic blood pressure	1%	0%	1%
Natural waist (cm)	1%	3%	5%
Umbilical waist (cm)	3%	2%	1.%
Hip (cm)	0%	-2%	2%

Steps per day

Average Steps per day (steps/day) were evaluated weekly for each participant. Data was analyzed using the percent change formula in excel. Percent change equations were used to evaluate the group mean and individual percent change from baseline to mid-point, midpoint to endpoint, and baseline to endpoint. A negative percent change represents an overall decrease, while a positive percent change represents an overall increase. The group mean was calculated utilizing Statistical Package for the Social Sciences (SPSS). This method of data analysis was utilized due to the small sample size. On average, there was the largest percent increase from time 0 to time 1. This was also true for all individual participants except for one. On average there was a decrease in steps per day from time 1 to 2, but an overall maintained increase in steps per day from time 0 to 2.

Average Steps per day at each time period				
	Time 0	Time 1	Time 2	Mean
Group Average Steps/day	5,465	8,392	7,420	7,092 ±1217
Participant 1 steps/day	6,807	10,834	12,067	9,903 ±2246
Participant 2 steps/day	3,855	8,446	4,850	5,717 ±1972
Participant 3 steps/day	5,732	5,846	5,342	5,640 ±216

Percent Change in steps per day at each time period			
	% Change for time 0 to time 1	% Change for time 1 to time 2	% Change for time 0 to time 2
Group Average Steps/day	54%	-14%	36%
Participant 1 steps/day	59%	11%	77%
Participant 2 steps/day	119%	-43%	26%
Participant 3 steps/day	2%	-9%	-7%

Barriers to physical activity

Barriers to physical activity were evaluated utilizing "8 roads to Health Barriers quiz". Participants were asked to answer 21 statements by "how likely you are to say…" response choices were 0= very unlikely, 1= somewhat unlikely, 2= somewhat likely, 3= very likely. Data was analyzed using the percent change formula in excel. Percent change equations were used to evaluate the group mean percent change from baseline to mid-point, midpoint to endpoint, and baseline to endpoint. The group mean was calculated utilizing Statistical Package for the Social Sciences (SPSS). This method of data analysis was utilized due to the small sample size. The higher the mean, the more likely on average participants were to say each statement. A negative percent change represents a decrease in likely hood for participants to agree with each statement.

Mean analysis on barriers to physical activity

Question (How likely are you to say…)	Time 0 Average	Time 1 Average	Time 2 Average
Physical activity takes too much time away from other commitments—time, work, family, etc.	2 ±1.5 somewhat likely	0 ±0.6 very unlikely	0 ±0.6 very unlikely
It's easier for me to find excuses not to exercise than to go out to do something.	3 ±0.6 very likely	1 ±1.2 somewhat unlikely	1 ±1.2 somewhat unlikely
I'm too tired during the week and I need the weekend to catch up on my rest.	1 ±0.6 somewhat unlikely	1 ±1.2 somewhat unlikely	0 ±0.0 very unlikely
I want to get more exercise, but I just can't seem to make myself stick to anything.	3 ±0.6 very likely	1 ±1.2 somewhat unlikely	1 ±1.2 somewhat unlikely

Percent Change Analysis on barriers to physical activity

Question (How likely are you to say…)	Time 0 to 1	Time 1 to 2	Time 0 to 2
Physical activity takes too much time away from other commitments—time, work, family, etc.	-80%	0%	-80%
It's easier for me to find excuses not to exercise than to go out to do something.	-75%	100%	-50%

I'm too tired during the week and I need the weekend to catch up on my rest.	-50%	-100%	-100%
I want to get more exercise, but I just can't seem to make myself stick to anything.	-50%	0%	-50%

Motivation for Physical activity and exercise

Motivation for physical activity was evaluated utilizing the "RM 4–FM: Motivation for Physical Activity and Exercise/ Working Out—Questionnaire". Participants were asked to answer 16 statements by "Using the rating scale provided below, please indicate how true each of the following reasons is for why you are, or would like to be, active regularly" with the scale range from 1 to 7. 1= never true, 4= neutral, 7= always true Data was analyzed using the percent change formula in excel. Percent change equations were used to evaluate the group mean percent change from baseline to mid-point, midpoint to endpoint, and baseline to endpoint. The group mean was calculated utilizing Statistical Package for the Social Sciences (SPSS). This method of data analysis was utilized due to the small sample size. The higher the mean, the truer on average participants felt each statement was. A positive percent change represents a increase in truth of each statement

Mean analysis for motivation for physical activity

Question (How true each of the following reason is for why you are or would like to be, active regularly…)	Time 0 Average	Time 1 Average	Time 2 Average
because it is a challenge to accomplish my goal	5 ±4.7 Sometimes true	6 ± 1.7 Usually true	6 ±1.7 Usually true
because I believe physical activity helps me feel better	6 ±6.0 Usually true	6 ±1.2 Usually true	7 ±0.6 Very true
because it's fun	4 ±3.4 Somewhat true	5 ±1.7 Sometimes true	5 ±1.7 Sometimes true
because it is interesting to see my own improvement	5 ±4.7 Sometimes true	6 ±1.2 Usually true	6 ±1.7 Usually true

Percent change analysis for motivation for physical activity

Question (How true each of the following reason is for why you are or would like to be, active regularly…)	Time 0 to 1	Time 1 to 2	Time 0 to 2
because it is a challenge to accomplish my goal	29%	0%	29%
because I believe physical activity helps me feel better	6%	5%	11%
because it's fun	36%	0%	36%
because it is interesting to see my own improvement	36%	-5%	29%

Motivation for joining LAST & expectations

Motivation for joining the LAST Study and expectations for the study were qualitatively analyzed through a focus group phone interview with each participant. Participants were asked a series of 15 questions.

Question	Participant 1 response	Participant 2 response	Participant 3 response
1. What prompted you to start the program?	To get myself moving again	Had been exercising in the past, but got out of routine due to increase in responsibilities at work. Saw this as an opportunity to get back in the swing of things	Something I had been interested in, seemed the perfect fit and I enjoying working with students
2. What expectations did you have when beginning the program?	Developing a new routine… forming a new habit again	That it was going to get me back up and moving… increasing my steps each day…closer to 10,000 steps per day that I had been doing for awhile	I didn't really have, expect well that is was going to be hardcore and full of rules, do's and don'ts, and I found that not to be the case which actually made

			it all the more enjoyable

Discussion

Development and Novelty

This study was conducted in order to understand the relationship between risk factors associated type 2 diabetes mellitus (T2DM) and increased leisure time physical activity and the consequent adherence to behavior modification after completing a 6-week intervention program. Furthermore, and exploration of individualized goal setting and the use of technology was examined utilizing individualized step goals and FitBits. Such exploration is important to understanding as new intervention programs are created to increase physical activity levels. Secondly, group meetings, education, and support proved to be an effective way to provide positive results in increasing leisure activity, motivation, and barriers. This study is novel in that it independently exploring the ability for individuals to set and achieve goals while also feeling supported by a group.

Anthropometric Assessment

Analysis of anthropometric data did not yield large percentages of change at any time point in the study. The largest percent change was in systolic blood pressure (-17%). While all other assessments changed by less than 6%. This means that this intervention program likely did not span long enough to see significant changes in anthropometric assessments. The standard time for most health behavior interventions in at least 6 months. This is important, because it reveals that in order to see significant changes in anthropometric assessments longer time frames of intervention and observation may be necessary moving forward.

Average steps per day

Analysis of average steps per day yielded large percentages of change throughout each time point in the study. From time 0 to time 1 on average their was a 54% increase in average steps per day. This means that in 6 weeks, on average, all participants increased their activity level. From time 1 to time 0 their was a -14% decrease in average steps per day. This means that participants activity level was not maintained at the same level as it was while they were in the active phase of the intervention. However, overall from time 0 to time 2 on average their was a 36% increase in steps per day. This means overall their average steps per day remained higher after 12 weeks than it did prior to the study. This is important to understand because it evaluates the adherence to increase physical activity. Participants adherence to increase steps per day was highest when they were actively involved in an intervention (meeting weekly, setting step goals, and completely social media discussions). However, even though the increase was higher during active intervention, the participants still maintained an overall increase amount of steps per day at the completion of 12 weeks.

Barriers to PA

Analysis of the barriers to physical activity yielded significant decreases to some common barriers. For this measurement, a negative percent change correlated with each statement being less of a barrier. The common barriers identified included; time, excuses, too tired, and inability

to stick with any form of PA. The barrier of time was reduced by 80%. This means that though this intervention, which focused on leisure time PA, participants were able to overcome the barrier that PA took too much time, by incorporating PA into their daily routine. The feeling of being too tired to exercise was reduced completely by time 2, This is important to addressed because it means that as participants increased PA levels, they actually experienced more energy. and were less tired daily. This is a common benefit of PA that gets overlooked, as many perceive exercise to be tiring instead of energizing. Excuses for PA and inability to stick to something were also reduced. This means that participants found it more challenging to make excuses to not exercise. This is related to the decrease in participants belief that they are unable to stick to something. By participating in this intervention, participants found a form of increase PA they could stick too, which made PA more feasible.

Motivation for PA

Analysis of the motivation for physical activity yielded small increases in motivation on how likely participants are to engage in PA. The most significant motivating factors included goal accomplishment, feeling better, fun, interest in ones own improvement. Overall motivation for all of these factors increased slightly during the 12-week study. This means that the study was likely a contributing factor that lead to increased motivation related to these factors. It is important to consider motivation, and although motivation did increase, it was not as significant as increase as other measures, such as barriers to PA. This reveals that motivation may take longer to build, and may be more influenced by internal factors and less on external solutions that was provided in the study. This reflects the importance of intrinsic and extrinsic motivation.

Motivation for joining & expectations

Analysis of participants motivation for joining the study and expectations was qualitatively assessed through a focus group. Analysis revealed common themes among participants for joining and for their expectation of what they would get out of participating in the study. Participants were motivated to join the study by personal desires become more physically active. All had been active in the past. This means that the participants who joined the study and were retained throughout the 12-week study were likely in the preparation phase of the Transtheoretical model of behavior change. This is important because it reveals participants readiness to change. This program proved to be effective at changing PA behavior because these participants were ready to make a change and were in the search of something to move them into action. Analysis of participants expectations revealed that all participants expected to receive a new way of being physically active. One of the participants expected the study to be very strict with rules. This means that participants expectations also align with someone in the preparation phase of behavior change- as they are thinking through what they expect to happen if they choose to change or engage in a behavior. Understanding motivation to join and expectations, together, is important because it tell more about the type of participants this program is effective with and reinforces that the study did what participants were wanting/looking for.

Conclusions

It can be concluded that the tracking of leisure time physical activity did increase overall steps per day. All participants experienced an increase in steps per day during the active phase of the

intervention study. While increased varied from participant to participant, setting a daily step goal and group meetings proved to be effective in supporting a behavior change. However, during the inactive intervention, when participants were not required to set daily step groups or come to weekly group meetings, all 2/3 of participants experienced a decrease in average steps per day. This suggests that daily step goals and group meetings were key components of increased steps per day. This change is also reflected in changes in motivation and barriers to physical activity. When reviewing the results of barriers to physical activity, there was a range in percent change for different barriers, from 50% to 80% during time 0 to 1, while some of these barriers seemed to increase during the inactive phase, overall the decrease in barriers was maintained from time 0 to time 2. This reflects the active phases objective to help reduce barriers and find solutions to common barriers such as lack of time, equipment or being too tired. When reviewing motivation there was similar trends to barriers. Motivation seemed to be the most drastically increased during the active intervention, and then was slightly reduced during the inactive intervention, yet an overall increase was maintained over the duration of the 12-week study.

As indicated by the results, there was minimal changes in biometric assessments. In fact, on average, participants natural waist and umbilical waist measurement increased minimally yet steadily over the duration of the study. Yet, body mass index (BMI) and hip measurements both minimally decreased over the duration of the study. Umbilical waist initially increased over the active phase, but then decreased after the inactive phase. These results do not support a drastic impact on management of T2DM in the context of 12 weeks. These findings may suggest that different biometric assessments, or a longer context of study be implemented.

Strengths/Limitations, Public Health Impact and Future Research

Limitations of this study primary exist in the small sample size; future research should reproduce a similar study on a larger scale. Furthermore, for more impactful results on biometric assessments, a longer study duration should be implemented- as 6 months is typically standard practice for many intervention programs with aims at reducing disease related risk factors. As a pilot study, this research lays the groundwork for further exploration of leisure time physical activity2 tracking and defines a need and means for improve longer duration studies. The impact of such findings are important in that positive changes to physical activity levels can be produced as results of step tracking and individualized goal setting.

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