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Use of Fitbit Data to Evaluate the Effects of an Athletic Performance and Injury Prevention Training Program on Daily Physical Levels in Underrepresented Minority Female High School Athletes: A Prospective Study

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Abstract

A marginal number of adolescents meet the recommended guidelines of 60 minutes of moderate to vigorous daily physical activity, and even fewer underrepresented minority females achieve this metric as compared to their male and white counterparts. While potential interventions exist to address these low levels of activity, which is a known risk for acute injuries and chronic disease, there is lack of consensus on the devices used to measure the intensity of daily activity levels. Wearable activity trackers such as Fitbit™ have been utilized to quantify human motion and exercise intensity, but there is little precedence for these measures being assessed in adolescent wearers. Thus, our objective was to assess the feasibility of using Fitbit to assess daily physical activity levels in underrepresented minority adolescent females, who attend an economically challenged urban high school, over the course of a physical activity intervention. We also aimed to identify candidate Fitbit outcome measures for future prospective studies.

A 10-week physical activity intervention was implemented in a cohort of 24 high school female athletes. From within this cohort, a sample of five students were provided Fitbit™ devices, from which we obtained data sets from three students. Activity on the days of the exercise intervention was measured and compared to activity on non-intervention days. Post-hoc assessments were performed based on individual heart rate reserves, the predefined levels set by the Inspire Fitbit™ device and the American College of Sports Medicine (ACSM) 2009 guidelines.

The results showed that while compliance is challenging, wearable devices can be used to assess daily physical activity levels and intensities in underrepresented minority high school female athletes during an extended physical activity intervention. Of the Fitbit outcomes currently available, assessment of moderate-vigorous activity (min/day) appeared to be the best as a measure

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of global physical activity. Prospective research is now warranted to validate these thresholds, and to test novel interventions for their ability to transition inactive adolescents at risk of sports-related injuries and long-term chronic disease, into a more active lifestyle.

Keywords

female athlete; injury prevention; physical activity intervention; Fitbit; physical activity recommendations; physical activity intensity levels

INTRODUCTION

The recommended physical activity guidelines for adolescents are 60 daily minutes of moderate to vigorous activity with at least three days a week involving vigorous activity[1]. Moderate physical activity examples include bike riding, brisk walking and dancing; examples of vigorous level activities include running, martial arts and active games like tag[1]. According to NHANES data, only 20% of young adults and adolescents meet this requirement, which is worrisome in light of the United States' obesity epidemic [2]. Even more concerning is that a large gender and racial disparity exists within these numbers[3–7]. Females, particularly those of underrepresented racial minorities, most often do not meet these recommended levels in comparison to their male and white counterparts[5, 8]. This activity gap has short-term effects, with lower activity adolescents being observed to have a higher incidence of obesity and glucose intolerance during their adolescent years, in addition to long-term effects such as increased risk for development of cardiovascular disease and associated co-morbidities such as hypertension and diabetes, all of which decrease life expectancy[9–11]. An opportune time to intercede and decrease prevalence of these diagnoses, which greatly shortens lifespans and negatively impacts quality of life, may be during the formative, teenager years[12, 13].

Until recently, the gold standard for daily objective physical activity assessment were accelerometers[14]. While there is a plethora of supportive evidence on the validity of these devices, drawbacks and limitations also exist [15]. Their utility, which has been demonstrated within the lab setting, is not always able to be replicated pragmatically in real life settings[16]. Although these devices have continued to diminish in size, they are relatively larger on children, leading to discomfort. They also require specific instructions in location of placement on the body, which needs to be consistent throughout the intervention [17, 18]. Accelerometers can be expensive, limiting the ability of researchers to be able to study large populations[15, 16]. Additionally, they may be viewed as a research implement and therefore less likely to be utilized by participants as designed in the study methodology[19, 20]. More recently, fitness monitors have introduced an alternative technological method to objectively quantifying activity levels. These devices offer multiple benefits over accelerometers. They can be less expensive, they are often easier to position, are lightweight and are accepted in mainstream culture as wearables. This may increase the probability that they are more consistently worn which then leads to increased quantity and improved quality and reliability of the collection of the data they generate as previous data has shown their validity for physical activity studies [14, 21–23].

Recently, we developed and implemented a 10 week athletic performance and injury prevention program for adolescent high school students, and demonstrated the use of Patient-Reported Outcomes Measurement Information System (PROMIS) and Functional Movement System (FMS) outcomes[24]. To expand on this, we aimed to assess daily activity levels during a similar 10 week study in underrepresented minority female athletes monitored via Fitbit™ wearable technology. Our hypothesis was that the wearable devices would be able to distinguish thresholds between low, moderate and vigorous activity among student participants. Long-term, these thresholds could be validated for utilization in future prospective studies.

MATERIALS AND METHODS

This was a prospective cohort study of adolescent athletes enrolled in an athletic performance and injury prevention program. The pilot was administered in an urban high school setting during a 10-week program led by co-investigators in Fall 2019. Study participants were led through a three day a week exercise intervention that targeted all major muscle groups [24]. Out of the cohort's 24 participants, a sample of five were given a Fitbit™ (Inspire HR, United States, San Francisco, CA). Study participants were instructed by the research staff in use of the device and also to wear their assigned Fitbit™ device all day, removing only to bathe or charge the device. Wearage and device charge capacity was checked during the thrice weekly intervention sessions. All human subject research was performed following informed consent from a legal guardian and assent from the study subjects, on an Institutional Review Board approved protocol. A data agreement was made with the company for data access. Data was uploaded to the Fitbit™ database multiple times a day and then participant data was downloaded to an approved, secure University of Rochester database every 24 hours.

Our primary goals were to demonstrate the ability to consistently track physical activity levels via the Fitbit™ monitoring system in this pilot feasibility study. Daily Fitbit™ output obtained included minutes of activity, resting heartrate (HR) and heartrate during activities. Maximum heartrate and heart rate reserve (HRR) were calculated using participants' age and resting heartrate.

The American College of Sports Medicine (ACSM) categorizes physical intensity levels into distinct groups [25, 26]. These levels are determined from the calculated maximum heart rate and resting heart rate of individuals'. The levels assigned for heart rate data were predetermined by Fitbit™ , and so we retrospectively determined which ACSM intensity levels those categories best fit (Table 1).

The minutes assigned to each activity intensity group were calculated by the Fitbit™ device. Days on which the device was detected as being worn less than 12 hours a day were excluded from analyses.

RESULTS

Three female athletes were followed through a subsection of a 10 week physical activity intervention program (Table 2). A fourth athlete had data collected, but it was for less than

50% of the intervention timeframe and so her data was excluded. Another participant had to leave the program for personal reasons; therefore, her data was also excluded.

The Fitbit results showed that Participant 1 and Participant 2 did not meet the recommended daily 60 minutes of moderate/vigorous activity throughout the intervention, on either the days of the week with the activity intervention or without (Figure 1). However, participant 3 met the average daily activity recommendation on six intervention days. Appropriate device wearage varied from 41% to 97%.

DISCUSSION

To the end of establishing thresholds values to characterize an individual's activity as low, moderate, or vigorous, we performed post hoc analyses on various daily Fitbit measurements including: Steps, Minutes Sedentary, Minutes Lightly Active, Minutes Fairly Active, Minutes Very Active, Activity Calories, Resting Hours, Out of Range, Fat Burn, Cardio, and Peak. Of these, moderate-to-vigorous physical activity (MVPA) was best defined by the predefined Cardio and Peak Fitbit™ categories.

While various commercial wearable devices are now available to quantify daily activity in human subject research, we chose the Fitbit Inspire HR device largely due to its secure internet interfaces with the study subjects and our research database. Of note, some studies have shown that in comparison to validated accelerometers, Fitbit™ devices provided comparatively accurate estimates of sedentary activity, but overestimates MVPA under free-living conditions [27]. Additionally, it has been shown that the test-rest reliability of Fitbit is dependent on activity type, and has greater variation between sessions compared to other wearable devices [28]. Nonetheless, we found Fitbit™ suitable for the intended purpose, and the development of threshold values to evaluate groups of people a potential solution to the device's limitations in precision measurements.

Obtaining Fitbit daily activity data on underrepresented minority high school female athletes during a 10-week training program is feasible. Fitbit MVPA thresholds for moderate and vigorously active levels can be derived and used to evaluate the efficacy of an intervention aimed at improving sedentary life-styles.

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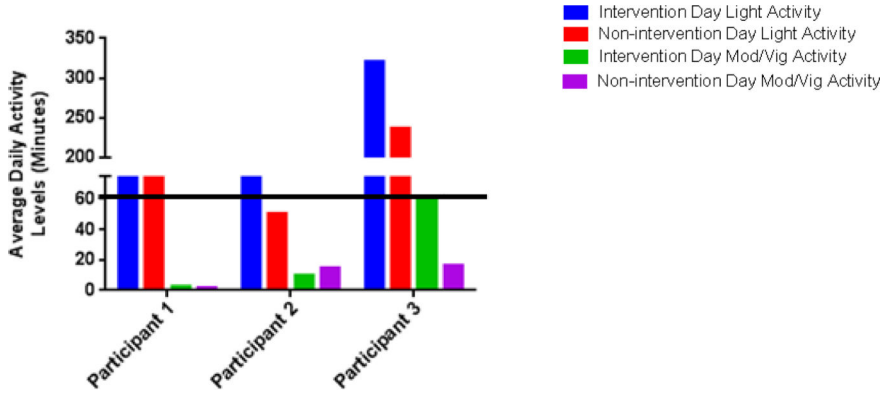

Figure 1: Participant Daily Activity Levels.

Each participant's daily activity was tracked via a Fitbit wearable device. Daily activity was segmented into two pre-defined sub-groups (Light Activity or Moderate/Vigorous Activity), and then further characterized as occurring on Intervention or Non-intervention Days. The ACSM Physical Activity recommendations for adolescents is also shown (line). The data shows that while neither participant achieved the average recommended daily activity level on non-intervention Days (purple), participant three did attain this level on Intervention Days (green).

Table 1:

Physical activity intensity categories of the Fitbit™ Inspire, study participants and the American College of Sports Medicine 2009 Guidelines

Target Heart Zones	**Inspire Fitbit™ Model (HR per min)**	**% of Max HR calculated (*using age = 16 and resting HR = 60)**	**ACSM Intensity**	**ACSM 2009 definitions of HR (%HR_{max}) intensities**
Sedentary	Out of Range: 30–102	0–29%	Very light	<57%
Low intensity	Fat Burn 102–143	29–57.6%	Light	57–63%
Moderate intensity	Cardio 143–174	58–79%	Moderate	64–76%
Vigorous intensity	Peak 172–200	79–111%	Vigorous	77–95%
			Maximal	>95%

Table 2:

Demographics and HR/HRR parameters of study participants

	Age	Sport	Mean resting HR	# of days of wearage	% of study days with appropriate wearage	HRR	Max HR
P1	15	Cheer	58	37	97%	127	185
P2	16	Basket-ball	58	27	41%	126	184
P3	16	Cheer	76	31	74%	108	184