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Acceptability and Feasibility of Under-Desk Elliptical Trainers to Disrupt Sedentary Library Time Among Historically Black College and University Students

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Abstract With evolving technological advancements and rising rates of sedentary occupations, sedentary behavior has become increasingly common. Prolonged and routine bouts of sitting time have been shown to cause various health problems. Interventions counteracting sedentary behaviors have been developed for occupational and academic environments. Historically Black Colleges and Universities (HBCUs) and on-campus libraries are understudied settings for sedentary interventions. This study reports a mixed qualitative-quantitative methodology to examine the feasibility and acceptability of under-desk elliptical trainers (UDETs) in an HBCU library setting among library staff members (Study One) and library patrons (Study Two). In Study One, eight library employees completed pre and posttest interviews regarding the feasibility and acceptability of UDETs in the library. In Study Two, student UDET use was tracked in an HBCU library for eight weeks, and participants completed self-report questionnaires while using the devices. In Study One, library staff participants reported generally favorable views toward UDET placement in the library, however voiced a need to retrofit the library environment to better suit UDET use. In Study Two, participants reported sitting an average of 3.5 hours/day in the library and 8.10 hours/day on weekdays. On average, UDET users pedaled 16 minutes/day, burned 7.03 kilocalories (kcals)/day, and reported the devices were "easy to use" and "could be used in the library setting." All UDET feedback participants endorsed wanting the devices to remain in the library permanently. Findings support UDETs as feasible and acceptable by library staff and students and effective in disrupting sedentary time, especially when UDET placement occurs in the context of supportive messaging to support UDET use.

Keywords: *sedentary behavior, Historically Black College and University, Under Desk Elliptical Trainer, library, retrofit*

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1. Introduction

With technological advancements and rising rates of sedentary occupations in the U.S., sedentary behavior has become increasingly common throughout the lifespan [1,2,3]. Sedentary behavior is defined as any waking behavior characterized by an energy expenditure (EE) of $\leq$ 1.5 metabolic equivalents (METs) while in a sitting, reclining, or lying posture [4]. Within the past 60 years, the U.S. has experienced a 28% decrease in moderate-intensity occupations and a 23% increase in sedentary and light intensity occupations [5]. Thus, a substantial decrease in daily occupational-related EE of 140 kilocalories (kcals) for men and 124 kcals for women has been observed [5]. The average U.S. adult spends anywhere from 54-57% of their total waking hours sedentary [6,7].

More than four hours of inactive sitting leads to inflammation, whereas more than nine hours increases the risk for all-cause mortality, indicating that sedentary individuals are at an increased risk of developing chronic health problems [8,9]. Prolonged bouts of sedentariness have been identified as impairing one's health regardless of physical activity levels [9,10]. Sedentariness is considered an independent risk factor that has been shown to be linked to non-communicable diseases, such as cardiovascular disease, type II diabetes, colorectal cancer, and metabolic syndrome [11-15].

Sedentary behavior increases throughout the lifespan, with children, adolescents, and adults dedicating more time toward screen-based and occupational-related activities as they age [2,16]. College-aged adults are also at an increased risk, as this population spends approximately 61% of their day sedentary [17,18,19]. In 2012, 40% of college-aged adults between the ages of 18 and 24 were overweight or obese [20]. Moreover,

undergraduate and graduate enrollment is expected to increase by three percent by 2028 [21]. With large portions of overweight college students and the projected increase in postsecondary education, college adults are at risk of experiencing deleterious health outcomes related to sedentariness.

African Americans experience higher rates of cardiovascular disease, type II diabetes, colorectal cancer, and metabolic syndrome when compared to Caucasians [22,23,24,25]. African Americans spend more time dedicated to screen-based activities and have lower levels of physical activity when compared to other demographic groups [26,27]. This may in part explain why African Americans disproportionately bear the burden of health conditions directly associated with sedentariness [22,23,28,29]. Since prolonged sedentariness is linked to harmful health outcomes, African American college students face an increased risk of developing such chronic diseases.

In addressing the sedentary epidemic, researchers have focused their attention on using light-intensity exercise interventions through active work desks as a preventative measure [30]. Engaging in as little as one minute of light-intensity exercise has been shown to offer metabolic benefits [31]. Active work desks, such as treadmill and pedal desks, have been shown to reduce sedentary behavior in the workplace and increase EE in both lean and obese participants [32,33,34]. However, users of treadmill and pedal desks commonly experience decreases in work performance, and users of pedal devices report problems with their knees hitting the underside of the desk, feet slipping off pedals, and chairs sliding away from the pedaling devices [34,35].

To address these concerns, under-desk elliptical trainers (UDETs) have been implemented in work settings to reduce excessive sedentariness while maintaining work productivity [36,37,38]. As opposed to the up and down motion of pedal devices, UDETs have a forward and backward elliptical motion, which minimizes the risk of users hitting their knees on the underside of their desks. Compared to inactive sitting or standing, both healthy and obese UDET users burn more calories per hour, experience higher elevations in heart rate and oxygen consumption, report little to no musculoskeletal discomfort, and exhibit minimal reductions in motor or cognitive performance [36,37,39]. UDET users also report positive experiences with and perceptions of UDET devices [36,37,38,39]. Disrupting prolonged sedentary bouts with light-intensity physical activity via UDETs offers metabolic benefits while maintaining work productivity and minimizing risk of injury [36,37,39].

1.1. Problem

Similar to the workplace, academic environments have been modified to promote movement [35,40,41,42]. Pedal devices and standing desks in campus libraries and classrooms are feasible and acceptable among both students and instructors [35,40,41,42]. However, prior studies have several limitations. Only two studies have retrofitted library environments to reduce academic sedentariness [35,40]. Similar to classrooms, libraries are predominantly sedentary environments, and African American students use on-campus libraries more frequently than Caucasians [43,44]. Student pedal desk users also commonly reported usage issues associated with bumping their knees on the underside of their desks and declines in typing and mouse pointing performance [35,40,45]. Students who use standing desks also complain of spinal discomfort, fatigue, and joint pain, which are common side effects of prolonged standing [34,40,42,46]. Inactive standing is also a known risk factor for health problems, such as heart disease, knee osteoarthrosis, and oxidative stress [47]. Further, prior usage studies in colleges have inquired about general demographic characteristics; yet, racial and ethnic composition of participants in prior studies are unknown [35,40,41].

Building on previous findings and addressing these limitations, this study introduced UDETs in a HBCU library to examine the acceptability and feasibility of these devices. Data were collected from both library staff members and student UDET users. First, it was hypothesized that UDETs would be regarded as feasible and acceptable among library patrons and staff members. Secondly, it was hypothesized that UDETs would disrupt sedentariness among library patrons. Thirdly, it was hypothesized that UDETs would be considered feasible and acceptable among library patrons.

2. Methods

The study employed a mixed qualitative-quantitative research design to examine UDET acceptability and feasibility. In Study One, pre and posttest interviews with HBCU library staff members were completed to elicit attitudes and concerns about UDET use in the library. Study Two was a community intervention in which UDETs were placed in the library. Observational and self-report data were collected to examine UDET use and user perceptions and attitudes. All data were then evaluated to estimate the feasibility and acceptability of giving access to UDETs in an HBCU college library.

2.1. Participants

The participant sample recruited for Study One consisted of library staff members (N=8) aged 18 years or older who were currently employed at an HBCU located in the Delta South (see Table 1). Most participants identified as female, Black, or African American. All staff participants gave informed consent.

The Study Two sample consisted of HBCU students aged 18 years of age or older who were enrolled at an HBCU in the Delta South and who also patronized the university library. There were two types of participants in Study Two: UDET users who used UDETs during the study and UDET feedback providers who were randomly selected to complete self-report measures. The study design did not permit a counting of UDET users, but their data was telemetrically collected. No written or verbal informed consent was considered necessary of UDET user participants, as no individually attributable data was collected from them. All UDET feedback providers gave oral consent. Sociodemographic characteristics of UDET feedback providers are presented in Table 2.

Table 1. Sociodemographic Characteristics of Study One Participants (Pretest and Posttest)

Pre and posttest characteristics	Pretest (n=5)	Posttest (n=3)
Gender		
Male	3	0
Female	2	3
Ethnicity		
African American	4	3
Asian	1	0
Highest education level		
Highschool/some college	1	0
Bachelor's degree	1	1
Postgraduate degree	3	2
Time employed by library		
2-5 years	3	2
5-10 years	0	0
10-20 years	2	1

All participants identified as either Black or African American and were mostly female. On average, participants reported sitting 3.5 hours per day in the library.

2.1.1. Instrumentation and Apparatus

In Study One, pre and posttest participants were asked a series of questions concerning their demographics and perceptions of UDETs. The UDET manufactured under the trade name activeLife Trainer™ was introduced to pretest participants during the interview.

Table 2. Sociodemographic Characteristics of Study Two UDET Feedback Providers

Full Sample		
Sociodemographic	N	%
Age		
18-24	9	100
25+	0	0
Gender		
Male	2	22.0
Female	7	78.0
Other	0	0
Race/ethnicity		
White, non-Hispanic	0	0
Spanish, Hispanic, Latino	0	0
Black or African American	9	100
Asian	0	0
American Indian or Alaskan Native	0	0
Native Hawaiian or Pacific Islander	0	0
Other	0	0
Employment		
Student	9	100
Non-student	0	0
Student classification		
Freshman	1	11.0
Sophomore	1	11.0
Junior	4	45.0
Senior	3	33.0
Postgraduate	0	0
Major		
Biology	5	56.0
Chemistry	1	11.0
Computer science	2	22.0
Psychology	1	11.0
Hours per/day sitting in library		
Less than 1 hour		
1-2 hours	2	22.0
3-4 hours	4	45.0
5-6 hours	3	33.0

Note. N = 9. Participants were on average 20.6 years old (SD = 1.1).

The activeLife Trainer™ was chosen, because its use poses no greater risk than walking, incorporates an attachment plate that stabilizes the device during use, and enables users' chair wheels to be fixed in place. This UDET mitigates against injury, because it is self-powered, has joint friendly leg geometry, and has adjustable resistance levels. Even a low resistance level roughly doubles metabolic rate [37]. Additionally, the activeLife Trainer™ has a Bluetooth low energy cadence sensor, which allows telemetric tracking of its use.

One Apple iPod ™ (6th Generation), running the Cateye Cycling™ mobile application (app), was used to track usage data during the interview [48,49]. An Apple iPod™ was used due to its Bluetooth 4.1 capabilities and compatibility with activeLife Trainer's™ built in cadence sensor. Cateye Cycling™ is a free mobile app that records and measures cycling data. With the help of this software, pedal time, cadence, speed, and distance were displayed to pretest participants who opted to use the UDET during the interview. One Apple iPhone ™ (7th Generation) was used to audio record participant responses to the interview questions [50].

In Study Two, the following UDET intervention protocol was implemented: three UDETs were placed on the second floor of an HBCU library in the Delta South. Each device was placed under a one-person table. UDETs were connected to their own iPod that ran the Cateye Cycling™ software. All tabletops included an affixed explanation on how to operate the UDET. UDET using participants were recruited via different printed materials, including an advertisement flyer, an article in the student paper, and posters. Posters were positioned on the first and second floors of the library and detailed the health risks associated with sitting and introduced UDETs as a way to disrupt sedentariness. An article was published in the student newspaper, which detailed the location of the devices, risks associated with sedentariness, and benefits of UDET use. UDET users were also alerted to the presence of UDETs in the library via tabling events that took place on campus.

UDET feedback providers voluntarily completed a demographic questionnaire, the Feasibility/Acceptability Questionnaire, the Short-Form International Physical Activity Questionnaire (IPAQ-Short Form), and the Barriers to Being Active Quiz (BBAQ). The demographics questionnaire included questions about age, gender, ethnicity, level of education, enrollment status, and time spent in the library. The Feasibility/Acceptability Questionnaire consisted of a 22-item, five-point Likert scale survey which was adapted from previous UDET studies [35,51]. Participants endorsed ratings on a five-point Likert scale ranging from (1) strongly disagree to (5) strongly agree. Observed Cronbach's alpha in this study for the 22 feasibility/acceptability items was α=.86. The IPAQ-Short Form was used to evaluate UDET feedback providers' level of physical activity. The IPAQ-Short Form was developed as a monitoring instrument for levels of physical activity and inactivity. The IPAQ has been studied among a variety of diverse populations as well as with college students [40,52]. The IPAQ-Short Form demonstrates acceptable reliability and validity (reliability correlations between 0.34 to 0.89 and criterion

validity correlations from 0.14 to 0.53) among an HBCU population [52].

The BBAQ was used to assess UDET feedback providing participants' perceived barriers to physical activity. The BBAQ is a 21-item public domain questionnaire that provides a measure of seven common barriers to physical activity. Items are rated on a four-point Likert scale from (0) very unlikely to (3) very likely. The BBAQ was created to help participants and clinicians target specific barriers to improve physical activity. The BBAQ has been used with college samples and has been shown to have good distributions between all items (SD = 1.22 - 2.92), acceptable internal consistency (α = 0.81 - 0.84), and satisfactory test-retest reliability (intraclass correlation coefficients = 0.46 - 0.87) [53,54].

2.1.2. Procedures

Before Study One, screening measures were completed with the library director to determine eligibility to participate. Only staff email addresses for those who spoke English, were at least 18 years of age, and were current library staff members were included. Library staff participants were recruited by email and in person. Pre and posttest interviews took place individually. After participants provided written informed consent, pretest interviews took place in person prior to the implementation of UDETs in the library in Study Two. Pretest interview participants were introduced to the UDET and were explained the device's purpose, benefits, and use. Each participant was given the option to use the device during the interview. After completion of Study Two, pretest participants received an email about posttest interviews. Posttest interviews were conducted using the same procedures outlined above. All interview data was recorded on a password protected cellphone, and audio data was transcribed verbatim.

In Study Two, telemetrically obtained UDET use data, including total pedal time across all UDETs, were tallied daily. All UDET users were anonymous. UDET feedback providers were randomly recruited among UDET users during one-hour observational sweeps. Of note, mask use was mandatory in the library, as Study Two took place during COVID-19. There was no compensation for participation. All data were collected between March 2021 and December 2021.

2.1.3. Data Analysis

Study One utilized thematic analysis to qualitatively investigate elicited themes and codes from pre and posttest interviews [55]. A "six-phase guide" to conducting thematic analysis was utilized to organize themes [56]. Thematic analysis elicited distinct concepts in both pre and posttest data sets.

In Study Two, the Cateye Cycling™ app tracked UDET pedal time, trip distance, average and maximum speed, average and maximum cadence, and kcals burned. These values were recorded daily in 24-hour intervals over a three-month span. Data was analyzed with SPSS 28 (IBM, Armonk, New York, U.S.A). Values were expressed as mean $\pm$ standard deviation (SD). For self-report measures, means and SD were computed for demographics, physical activity, sedentary behavior, barriers to physical activity, and patron feasibility/acceptability. Means and Chi square tests were used for categorical variables, and analysis of variance was used for numerical variables. Data were collected following permission from the Research and Ethics Boards of all participating institutions.

3. Results

3.1. Study One

The first research question asked how feasible and acceptable HBCU library staff members found UDETs in the library environment. Thematic analysis conducted on interview transcripts produced a total of four themes: 1.) "Acceptability to Library Environment," 2.) "Anticipated Acceptability to Patrons," 3.) "Feasibility to the University," and 4.) "Effect of Student Intersectionality on UDET Feasibility."

Acceptability to Library Environment

Over half of the participants discussed how UDETs could benefit students and the library environment. For example, one pretest participant stated: "When you are in a library, you are there to read or study and it is quiet. Studying from one to six hours can be boring, so … [a UDET] just being on here kind of makes the studying more fun. I mean, studying is never fun, but it can be fun if you make it fun. I feel like it [UDET] gives you an intensity to studying as opposed to just being stale."

All pre and post implementation participants described various ways UDETs could be utilized in the library, noting positive implications for increasing physical activity, disrupting sedentary behavior, enhancing cognition, benefitting mood, and increasing productivity and motivation. For example, one pretest participant explained: "I can see it being helpful, especially during midterms and finals when students start stressing out." One posttest participant stated: "If you are reading scholarly articles, maybe this will keep you alert. That could be an advantage." When offered to use the UDET during the interview, all but one pretest participant utilized the device throughout the entirety of the interview.

However, most pretest participants voiced concerns with UDET placement, either describing which floor(s) UDETs should be placed on, types of rooms appropriate for use, or timing of placement. Regarding floor placement, one participant stated: "I would not take this on the second floor. They will move it around, you know. I consider the first and third floors the study floors." Interestingly, UDET floor placement concerns appeared to change post implementation, as one post-test participant expressed: "I thought they [UDETs] would be a problem on the second floor because students move around a lot on that floor, but they actually did just fine where they were at."

More serious safety and distractibility concerns emerged among some pretest participants. One participant stated: "I would say that the disadvantage would be if students are not using it [UDET] properly." Conversely, one posttest participant specified: "Before the study, I thought that UDETs were going to be a distraction and that students were going to misuse the UDETs. But I no longer think that is the case. I never observed students getting distracted on these devices or throwing them around.

Since pre and posttest interviews elicited multiple opinions on UDETs, data triangulation was utilized to test the validity of UDET acceptability. To allow triangulation, a 10-point Likert scale was utilized to allow participants to rank their likelihood of recommending UDETs for the library setting, with (0) reflecting "not at all likely and (10) reflecting "extremely likely." Pre participant ratings averaged 8.4, indicating a moderate to high likelihood of participants recommending UDETs for the library environment. Post participant ratings averaged 9.2, indicating that participants likelihood of recommending UDETs for the library increased.

This theme appeared to remain stable over the study period, as two posttest participants provided examples of how UDETs could positively impact the library environment, noting how UDETs could increase the library's overall value and how they could provide students with more options to complete library-related tasks. One related statement was: "I think that in the library setting, in terms of using something like this [UDET] in the library, it could add value actually to the library - in terms of differentiating it as a space and giving it a new component."

Anticipated Acceptability to Patrons

Participants reported variable perceptions to how students would react to UDETs in the library setting. For example, half of pretest participants indicated that students would react positively to the UDETs, while the other half expressed how students would be uninterested in using the devices either due to fears of sweating or having difficulties staying focused. "I think they will mostly like it. Most of them will think it is interesting," while another opined: "I have some friends who are pretty easy to lose their attention. So, this will really, really lose their focus on what they are doing. They need to avoid any kind of things on the side, even if it is just a little bit of noise."

Posttest participants voiced similar opinions, as one participant indicated: "I saw some students using the device. Some came into my office and asked me how to operate it [UDET]. But I also saw some students glance at it [UDET] and walk away to another table."

Anticipated acceptability appeared to remain stable throughout the study, as pre and post-test participants anticipated that students would be either interested or uninterested in UDET placement in the library.

Feasibility to the University

Four pretest participants expressed their assessment of the overall practicality of placing UDETs within the library setting, noting concerns of financial loss, liability, and increased employee tasks. "The only disadvantage would be wasting money. Just waste of equipment for nothing you know."

Post implementation, UDET practicality concerns lessened over time, as none of the posttest participants reported concerns about financial loss, liability, and increased employee tasks. Regarding liability, one participant noted: "I thought the students might hurt themselves on this device [UDET]. You never know. But they did just fine. I do not think it is dangerous in any way."

All pre and post implementation participants discussed how the library would need to retrofit its' environment to create a more suitable space for UDET use. Participants placed specific emphasis on creating designated workstations to prevent potential problems with students' moving the devices around. One pretest participant expressed: "If they are in just study rooms, students may think that they are mobile and may want to move them from one room to the other, as opposed to if you see it in a certain area that this is applicable for," while one posttest participant noted: "Do we have something to make this device moveable? Because as some staff said, I mean, we do not want students to move these devices and put them somewhere. We have a lot of staff in the public area. We do not want them to move, because it may cause problems if they move them [UDETs]."

Effect of Student Intersectionality on UDET Feasibility

Half of the pretest participants discussed whether UDET feasibility would be impacted by user intersectionality, such as whether UDETs could provide positive benefits to college students (athletic and non-athletic), sedentary individuals, elderly individuals, diabetic individuals, and neurodiverse individuals. For example, one pretest participant stated: "For a person that likes to sit and just do computer work, for them, it might be ideal from a health standpoint, because you cannot just sit all the time. You have to move, you know. So, I feel like it would be more ideal for a student in that nature. It is also ideal for people that are going deeper into their profession, because you know, it is a lot of time, and it is stressful. So, this can really help, too."

Post-implementation, one participant described: "I think it is really helpful for our students who are more sedentary - the ones who are in the library for hours without any movement."

3.1.1. Study Two

The second research question asked to what extent UDETs disrupted sedentariness among library patrons. Regarding UDET use, total pedal time across all three devices was 29 hours, with individual users averaging 16 minutes of pedaling per day (see Table 3). On average, users pedaled 0.83 miles per day and burned 7.03 kcals per day respectively.

Table 3. Library UDET Utilization Data Over 56 Total Days

UDET user pedal data	Total	M (SD)
Pedal time (hrs/min/sec)	29:59:12	0:16:40 (0:25:35)
Trip distance (miles)	90.54	0.83 (1.56)
Energy Expended (kcal)	759	7.03 (14.45)

Overall UDET pedal time progressively declined over the course of eight weeks (see Figure 1). UDET use increased by three hours across all three devices during the first two weeks and then stabilized during weeks three and four during midterms. Interestingly, a two-hour increase in UDET use across all three devices was observed after the article was published in the student newspaper between weeks seven and eight. Across a total of 36 observational sweeps, one device was in use 19.44% of the time, two devices were in use 16.67% of the time, and three devices were in use 2.78% of the time. Regarding observed gender differences, 90.90% of users were observed to be phenotypically female and 9.10% were observed to be phenotypically male. Of note, gender expression of UDET users were unknown; however, the primary investigator made inferences on gender differences in UDET use based on physical characteristics and gender expression of UDET users.

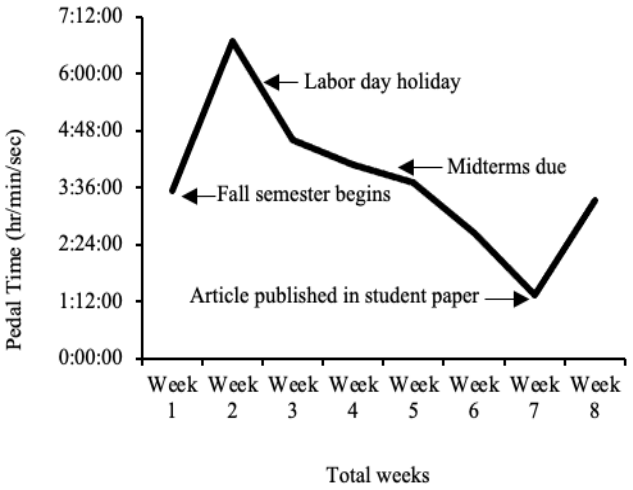

Figure 1. Library UDET Utilization Data Per Week

As for non-telemetric self-report measures, the IPAQ results showed that on average, participants reported engaging in vigorous physical activity 3.0 days/week (median = 2.50), moderate physical activity 1.25 days/week (median = 1.0) and walking for at least 10 minutes 5.78 days/week (median = 6.0) (see Table 4).

Based on total volume and number of days and sessions of physical activity, participants were categorized into three separate groups: high (≥ 3,000 MET-min/week), less than high (≥ 600 MET-min/week), and low (≤ 600 MET-min/week). Overall, 44.44% of participants reported scores in the high range, 44.44% reported scores in the less than high range, and 14.30% reported scores in the low range. Although most participants reported being physically active, 66.67% of participants reported spending approximately 485 minutes (8.10 hours) sedentary on weekdays.

The third research question asked how acceptable UDET use would be in an HBCU library and how patrons would rate their feasibility. UDET feedback participants reported that UDETs could easily be used in the library setting (median = 5.0; see Table 5). Moreover, 100% of participants in this study reported wanting UDETs to permanently remain in the library environment.

Table 4. IPAQ Short-Form Quartile, Median, and Mean (SD) Responses

Please answer the following:	N	Q1	Median	Q3	Mean (SD)
During the last 7 days, on how many days did you do vigorous physical activities (i.e., heavy lifting, digging, aerobics, or fast bicycling)?	4	2.00	2.50	4.50	3.00 (1.414)
How much time did you usually spend doing vigorous physical activities on one of those days? [a]	4	37.50	90.00	142.50	90.00 (54.772)
During the last 7 days, on how many days did you do moderate physical activities (i.e., carrying light loads, bicycling at a regular pace, or doubles tennis)?	4	1.00	1.00	1.75	1.25 (.500)
How much time did you usually spend doing moderate physical activities on one of those days? [a]	4	48.75	75.00	112.50	78.75 (33.260)
During the last 7 days, on how many days did you walk for at least 10 minutes at a time?	9	5.00	6.00	7.00	5.78 (1.641)
How much time did you usually spend walking on one of those days? [a]	8	37.50	90.00	172.50	136.25 (150.896)
During the last 7 days, how much time did you spend sitting on a weekday? [a]	6	360.00	390.00	607.50	485.00 (211.636)

Table 5. Feasibility/Acceptability Quartile, Median, Mean (SD) Likert Scale Responses

Please rate how strongly you disagree or agree with each of the following:	Q1	Median	Q3	Mean (SD)
The pedal machine is easy to use.	5.00	5.00	5.00	4.78 (.667)
The pedal machine could be used in the library setting.	4.50	5.00	5.00	4.78 (.441)
I use the pedal machine as an alternative to sitting still.	4.00	5.00	5.00	4.56 (.726)
I feel comfortable using the pedal machine in the presence of others in the library.	4.50	5.00	5.00	4.78 (.441)
My school-related productivity decreases while using the pedal machine.	1.00	2.00	2.00	1.67 (.707)
The quality of my work decreases while using the pedal machine.	1.00	2.00	2.00	1.56 (.527)
The pedal machine interferes with my work-related tasks.	1.00	2.00	2.00	1.56 (.527)
The pedal machine is too noisy.	1.00	1.00	1.50	1.22 (.441)
I am more tired on days I use the pedal machine.	1.00	1.00	2.00	1.44 (.726)
I have more back pain on the day I use the pedal machine.	1.00	1.00	1.50	1.22 (.441)
I have more joint pain on the day I use the pedal machine.	1.00	1.00	1.50	1.44 (1.014)
I have more muscle aches on the day I use the pedal machine.	1.00	1.00	2.00	1.44 (.726)
My physical activity increases while at the library as a result of the pedal machine.	3.00	5.00	5.00	4.33 (1.000)
The time I spend being sedentary decreases while at school as a result of the pedal machine.	3.00	4.00	5.00	3.78 (1.394)
If my school offers pedal machines in the library, I will use it.	4.00	5.00	5.00	4.56 (.527)
I would use the pedal machine while at home.	3.50	4.00	5.00	4.11 (1.054)
I am not distracted while using the pedal machine.	2.00	4.00	5.00	3.56 (1.509)
I want the pedal machines to remain in the library permanently.	4.00	5.00	5.00	4.67 (.500)
I want more pedal machines in the library.	3.00	4.00	5.00	4.11 (.928)
The pedal machines do not clutter the library.	4.00	5.00	5.00	4.67 (.500)
I would visit the library more often if they had pedal machines.	3.00	3.00	3.50	3.33 (.707)
I can study/work normally while pedaling.	4.00	5.00	5.00	4.56 (.527)

Note. (N = 9) Responses were reported on a 1 to 5 scale, where 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree. Only those who reported UDET use or who were observed using the devices completed these items.

Table 6. BBAQ Quartile, Median, Mean (SD) Likert Scale Responses

Barriers	Q1	Median	Q3	Mean (SD)
Lack of Time				
My day is so busy now, I just don't think I can make the time to include physical activity in my regular schedule.	1.00	2.00	3.00	1.89 (1.054)
Physical activity takes too much time away from other commitment-time, work, family, etc.	.00	1.00	2.50	1.33 (1.225)
My free times during the day are too short to include exercise.	1.50	3.00	3.00	2.22 (1.093)
Social Influence				
None of my family members or friends like to do anything active, so I don't have a chance to exercise.	.00	1.00	2.00	.89 (.928)
I'm embarrassed about how I will look when I exercise with others.	.00	1.00	1.50	.78 (.833)
My usual social activities with family or friends do not include physical activity.	1.00	2.00	3.00	1.89 (1.167)
Lack of Energy				
I'm just too tired after work (or school) to get any exercise.	2.00	2.00	3.00	2.22 (.972)
I don't get enough sleep as it is. I just couldn't get up early or stay up late to get some exercise.	1.50	3.00	3.00	2.22 (1.093)
I'm too tired during the week and I need the weekend to catch up on my rest.	1.50	3.00	3.00	2.33 (1.118)
Lack of Willpower				
I've been thinking about getting more exercise, but I just can't seem to get started.	2.00	3.00	3.00	2.44 (1.014)
It's easier for me to find excuses not to exercise than to go out to do something.	.50	2.00	2.50	1.67 (1.118)
I want to get more exercise, but I just can't seem to make myself stick to anything.	1.50	3.00	3.00	2.22 (1.093)
Fear of Injury				
I'm getting older so exercise can be risky.	.00	.00	1.00	.44 (.726)
I know of too many people who have hurt themselves by overdoing it with exercise.	.00	.00	1.00	.67 (1.000)
I'm afraid I might injure myself or have a heart attack.	.00	.00	.00	.11 (.333)
Lack of Skill				
I don't get enough exercise because I have never learned the skills for any sport.	.00	.00	.50	.44 (1.014)
I really can't see learning a new sport at my age.	.00	.00	.50	.22 (.441)
I'm not good enough at any physical activity to make it fun.	.00	.00	.00	.11 (.333)
Lack of Resources				
I don't have access to jogging trails, swimming pools, bike paths, etc.	.00	.00	3.00	1.00 (1.500)
It's just too expensive. You have to take a class or join a club or buy the right equipment.	.00	1.00	1.00	.78 (.972)
If we had exercise facilities and showers at work (or school), then I would be more likely to exercise.	.00	2.00	3.00	1.67 (1.414)

Note. (N = 9) Responses were reported on a 1 to 5 scale, where 0 = very unlikely, 1 = somewhat unlikely, 2 = somewhat likely, and 3 = very likely.

When asked about impacts on health and behaviors, participants reported an increase in their physical activity due to UDET use and endorsed that they would use the devices if their school's library offered them (median = 5.0). When asked about work productivity, participants denied negative alterations in their school and work-related productivity (median = 2.0). Additionally, participants denied becoming distracted by UDET use (median = 4.0), noting a satisfactory ability to maintain their studies while pedaling (median = 5.0).

UDET feedback participants endorsed experiencing five out of seven total barriers to engaging in physical activity, such as lack of time, social influence, lack of energy, lack of willpower, and lack of resources (see Table 6).

Lack of energy was the greatest endorsed barrier. For example, 88.8% of participants endorsed feeling too fatigued after work or school to engage in physical activity. Participant endorsed sleep difficulties may in part explain the high reports of tiredness, as 77.8% of participants also noted difficulties with getting sufficient amounts of sleep. Of particular relevancy to this study, over half of participants endorsed an inability to make extra time for physical activity due to their daily schedule (median = 2.0). Interestingly, however, more than half of the participants endorsed that they would be more likely to engage in physical activity if their work or school gave them access to exercise facilities.

4. Discussion

In Study One, eight library staff members were interviewed before and after UDET implementation in the library to capture attitudes about UDETs and to develop strategies to address expressed concerns. Pre and post implementation interviews produced a total of four overlapping themes: 1. "Acceptability to Library Environment," 2. "Acceptability to Patrons," 3. "Feasibility to the University," and 4. "Effect of Student Intersectionality on UDET Feasibility." Acceptability to the library environment theme appeared to remain stable over the study period. For example, pre and posttest participants expressed unchanging views on how UDETs could positively impact the library environment (e.g., increase in value), how UDETs could benefit users (e.g., disrupting sedentariness), appropriate rooms for UDET use (e.g., group study rooms), and timing of UDET placement (e.g., midterms, finals). Pretest participants voiced UDET floor placement and safety and distractibility concerns; however, these concerns appeared to reduce overtime, as posttest participants noted more positive views toward floor placement and safety and distractibility potentials.

Regarding feasibility to the university, most pretest participants expressed UDET practicality concerns in the library (e.g., financial loss, liability, increased employer tasks). However, practicality worries decreased after

UDETs were placed in the library, as most posttest participants did not mention ongoing concerns. Pre and post implementation participants voiced unchanging views on the library's need to retrofit its' environment for UDET use by designating areas for workstations separate from public sitting and study spaces. With the use of the 10-point Likert scale, interview themes related to UDET feasibility were triangulated. Pre implementation Likert scale scores averaged 8.4/10, whereas post implementation sores averaged 9.2/10. These scores confirmed overall positive views of feasibility and acceptability of introducing UDETs into the HBCU library setting. Notably, all but one pretest participant opted to use UDETs throughout the entirety of their interviews, suggesting that to build support among library staff members, giving them access to UDETs may be helpful. Despite early mild reluctance, after successful UDET implementation, library staff members were overall very supportive of UDETs in the library.

In Study Two, UDETs were placed in the on-campus library to assess whether these devices disrupted sedentariness and to evaluate the feasibility and acceptability of UDETs among library patrons. Over the eight-week study period, library patrons pedaled over 10 minutes per day, just short of one mile. Although impact on sedentary behavior was modest, evidence suggests engaging in as little as one minute of light-intensity activity yields metabolic benefits [31]. Although UDET pedal time gradually decreased over eight weeks, UDET use increased by three hours across all three devices during the first two weeks, and then somewhat stabilized during weeks three and four during midterms. Following the publishing of the student newspaper article during week seven, a two-hour increase across all three devices was observed. This result mirrors a previous study where pedal time was observed to increase among library university patrons on days that advertisement prompts were shown [35]. In addition to the article, this study utilized posters, and the university's social media accounts to prompt UDET usage. Present findings suggest digital marketing, including social media, may positively influence patron engagement and usage of UDET devices. The frequency at which UDETs were utilized appeared also to be influenced by certain semester times. For example, a two-hour decrease was observed leading up to Labor Day (weeks two-three), and a three-hour decrease was observed leading up to Thanksgiving break (weeks seven-eight). This finding was also confirmed in observational sweeps conducted during these weeks, as there were fewer students observed occupying campus and library spaces.

All nine UDET feedback providers reported UDETs to be acceptable and feasible for completing sedentary tasks without disrupting or interfering with productivity. Participants reported that seated active workstations could be used in the library and would be beneficial for increasing physical activity levels. Notably, all participants endorsed wanting UDETs to remain in the library setting permanently, suggesting such devices are feasible and acceptable for disrupting library related sedentariness.

UDET feedback providers reported sitting 3.5 hours per day in the library. Although UDET feedback providers were predominantly active (44.44% highly active, 44.44% less than highly active), over half of participants endorsed spending 8.10 hours sedentary per weekday. This finding is replicated in previous studies that indicates college students spend approximately 8-10 hours per day sedentary during the weekday [17,18,19]. This finding is concerning, as sedentary behavior is an all-cause mortality risk factor independent of physical activity levels [9,10].

Moreover, participants noted many barriers to engaging in physical activity. Almost all participants noted lacking energy and over half reported lacking resources, such as exercise facilities. These findings support use of such relatively low-cost UDETs which only require light-intensity effort yet have been shown to roughly double metabolic rate even at low resistance levels [37].

In Study Two, it was hypothesized that UDETs would disrupt sedentary library time among library patrons and would be regarded as feasible and acceptable. The findings of Study Two suggest that UDETs can help reduce sedentariness among HBCU library patrons who view UDETs as feasible and acceptable. These findings replicate prior feasibility and usage studies in other settings demonstrating that active workstations are feasible and acceptable among college students and staff and contribute to reducing sedentary academic-related behaviors [35,40].

4.1. Strengths and Limitations

The naturalistic design, use of mixed methods to evaluate the intervention, and inclusion of multiple stake holders were strengths of this study. To date, no studies have investigated the use of UDETs to disrupt sedentariness in an HBCU population, which is subject to concerning related health disparities [22,23,34,25,28,29]. This study's emphasis on an understudied at-risk population for related health disparities is thus an important additional strength. Additionally, the ecological validity of this study makes it possible to disseminate this intervention to other real-world sedentary settings, such as campuses, classrooms, dorm rooms, and break rooms. An additional strength of this study was that UDET usage data was obtained during the COVID-19 pandemic. Despite potential limitations to breathing due to mandatory mask use, library patrons frequently used UDETs throughout the duration of eight weeks.

Multiple limitations of this study should be considered. Due to COVID-19, multiple staff members who originally participated in Study One's pretest interviews were no longer working with the library at posttest follow-up. Thus, Study One may not have fully captured library staff's reactions after the UDETs were placed in the library. Given the novelty of UDETs in academic settings, UDET users may have initially used the devices due to their innovative characteristics. UDET pedal time was the highest in the second week and continued to gradually decrease in the subsequent weeks only to rise again in the end. Early increased UDET use may have been attributable to novelty effects. Similar to previous findings, UDET use decreased over time, which may indicate the gradual loss of novelty effects [38,51]. Thus, novelty effects may have affected external validity. This study placed three UDETs in the middle of the second floor to catch patron's attention. This decision way made so that the iPods could be powered to track UDET usage. However, patron usage may have been higher if there

were more UDETs placed on varying floors and in diverse locations (i.e., study carrels, study rooms). Since UDET use was recorded anonymously, the primary investigator could not determine whether there were repeat users of UDETs. Although no repeat users were observed during weekly observational sweeps, library patrons could have realistically used the device repeatedly, which could thus confound daily use data. While the study did not account for the presence of repeat UDET users, future studies could additionally track whether patrons were repeat users as an indicator of intervention acceptability. Further, there was a clear indication that UDET use was positively impacted by the supportive utilization campaign which included posters, social media messaging and an article in student newspaper. Therefore, to optimize the impact of UDETs on sedentariness, consistent supportive measures are needed.

A further limitation is that there were considerable gender differences in UDET use with more than 90% female users. Depiction of a female in the advertisement prompt may have motivated women to use UDETs more in the library setting. Thus, advertisements displaying users of varying genders may promote more gender inclusion in UDET use. Gender equity may also be improved by adaptations to the furniture as one participant reported noted that the "desk was too low" to allow proper use. Desks utilized in this study were individual study desks that had a protruding steel bar attached to the underside of the desk. In anticipating difficulties with the study desks, pneumatic office chairs were offered for their adjustable height features. However, the office chairs were often removed from the active workstations by library patrons, which caused most users to use the library's wooden rocking chairs. UDETs use may thus benefit from supportive physical plant measures that allow adequate under-desk clearance and ergonomic chairs that permit free leg movement.

5. Conclusion

This study sought to examine the feasibility and acceptability of placing UDETs within an on campus HBCU library in the Delta South. The findings of this study support the use of UDETs to help HBCU students to overcome barriers to physical activity and reduced sedentariness. Although this is a relatively new area of research, previous studies, have similarly found that retrofitting libraries with active workstations appears feasible and acceptable among staff members and students. With the lack of access to sedentary disrupting interventions in college settings, there appears to be a great need for HBCUs to offer interventions, such as UDETs, to promote the health and wellbeing for a student body at risk of disparate physiological stressors. Given the low cost of UDETs compared to library furniture, college universities could purchase UDETs as one part of a comprehensive multipronged approach to promote student health.

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Competing Interests

MS has no competing interests. CL holds intellectual property rights to the UDETs used in this study.

List of Abbreviations

UDET: Under Desk Elliptical Trainer
HBCU: Historically Black College and University
EE: Energy Expenditure
METs: Metabolic Equivalents
IPAQ-Short Form: Short-Form International Physical Activity Questionnaire
BBAQ: Barriers to Being Active Quiz

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