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Determining Perceptions to Electronically-Delivered, Personally-Adaptive, Multimedia Exercise Prompts for Middle-Age Adults

PAULA-MARIE M. FERRARA†, ETHAN T. SCHALTEGGER*, CORY T. BEAUMONT†, and KELLEY STROHACKER‡

Kinesiology, Recreation, and Sport Studies Department, The University of Tennessee, Knoxville, Knoxville, TN, USA

†Denotes graduate student author, *Denotes undergraduate student author, ‡Denotes professional author

ABSTRACT

International Journal of Exercise Science 13(5): 979-995, 2020. Due to high interaction rates, smart devices are being utilized for mobile health (mHealth) interventions. Multimedia capabilities may be leveraged to improve mHealth exercise interventions. Our purpose was to explore individuals' perceptions of multimedia exercise prompts tailored to their immediate mental/physical states. Using electronic surveys, respondents provided in-the-moment ratings of emotional state, energy, fatigue, physical discomfort, and thirst, with higher scores reflecting a higher "readiness to exercise" (i.e., if a person is currently in a pleasant mood with high energy and low discomfort, he/she is likely to have a greater capacity for a larger dose of exercise). They were then provided with an exercise prompt designed to match their readiness to exercise, demonstrated via text and graphic interchange format (GIF) showing a research member completing the recommended activity. Survey data regarding GIF quality, self-efficacy, and methodological feedback were then collected and analyzed using a combination of parametric statistics and thematic analysis of open-ended feedback. Respondents (N=204; 47±10 years; BMI 29±6 kg/m^2) indicated GIFs loaded quickly (5.29±1.2, scale 0-6), were clear (5.36±1.1), and easily understandable (5.43±1.1). High task self-efficacy scores (9.34±1.62, scale 0-10) and statistically significant differences in coping self-efficacy (i.e., how well a person would be able to complete the recommended activity when feeling mentally/physically worse or better; $F=3.229$, $p<.01$) were found. Five themes relating to the exercise prompt were noted: improve attractiveness, limiting factors, exercise clarification, liked/understandable/doable, and disliked/unwilling to complete. Further refinement of these methods is warranted prior to using multimedia prompts to elicit actual exercise performance.

KEY WORDS: Physical activity, multimedia, mHealth, responsive, prescription, fitness, survey, Graphic Interchange Format

INTRODUCTION

Findings from the 2018 Physical Activity Guidelines Advisory Committee Scientific Report allude to the growing reach of smartphones in the U.S. and support their utilization in mobile health (mHealth) for physical activity promotion. Physical inactivity contributes to various comorbid diseases (e.g., obesity, type II diabetes, cardiovascular disease) that increase

premature mortality among adults in the United States (20) and increase economic burden (27). As of 2014, only about 20% of Americans meet the recommended physical activity guidelines for aerobic and resistance activity (28). A common method of achieving these physical activity guidelines is through exercise, a subset of physical activity that is planned, structured, and completed with the intent to improve or maintain one or more components of physical fitness. Historically, exercise interventions have been delivered using in-person formats, but with the rapid development in mobile phones, smart devices, and global internet connection, the use of electronic and mHealth interventions is growing.

The use of short message service (SMS; i.e., text messaging) is a commonly implemented strategy for behavioral intervention, likely due to its high interaction rates (21). In 2013 it was reported that 99% of all text messages received are opened, with 93% opened within the first three minutes of receipt (34). Further, as of 2015, 81% of Americans utilize SMS for communication (33). Regarding physical activity promotion specifically, mHealth functions through SMS via both passive (e.g., reminders to get up and walk) and interactive (e.g., advice through counseling) means. Across two meta-analyses and one systematic review (5, 11, 12), moderate evidence was found that supports the use of SMS interventions to increase adults' physical activity behavior, with positive significant effect sizes found over control groups ($R \geq 0.40$) and a median effect size of 0.50 found in the systematic review (26). However, compared to cellular phones, smartphones provide an advanced range of capabilities in addition to text messaging, including internet access, Bluetooth, and the utilization of multimedia (e.g., pictures, videos). These more advanced capabilities may be leveraged to augment the promotion of healthy behaviors and be more feasible to utilize, as growth in smartphone ownership has been noted across all adult age groups 40).

Visual social media (e.g., selfies, memes, emojis) has become an increasingly popular and effective method of communication between mobile devices and on platforms such as Facebook, Instagram, and Twitter (13). In addition to text prompts, Graphic Interchange Formats (GIFs) are a form of media accessible by smartphone that could be utilized in SMS interventions to promote safe practices and improve participants' understanding of physical activity messages. GIFs are short, soundless, animated images, and the second most common image format used on the World Wide Web after the JPEG (Joint Photographic Experts Group) (42). In an analysis exploring GIF engagement on the social media platform Tumblr, participants cited the use of GIFs to convey thoughts and emotion is preferential for various reasons, such as the animation, lack of sound, immediacy of consumption, low bandwidth, minimal time demands, storytelling capabilities, and utility to express emotion (3). Compared to still images of JPEGs, GIFs can show an exercise movement in its entirety, providing a more dynamic understanding of a single activity, rather than just the beginning and ending positions. In comparison to traditional videos, GIFs are shorter in duration and "loop" continuously; there is no need to play, pause, or rewind the animation because it replays automatically (3). This repetition allows a person to follow along with a movement more easily because they do not need to continuously interact with the device (e.g., starting, pausing, replaying a video). Additionally, because GIFs are not audible, there is no need for headphones or to mute a device in order to retain privacy (3). Further, because of their lower memory cost, GIFs can be attached in text messages more easily

than videos and take less time to load from an Internet link. To our knowledge, the use of GIFs is minimal, if not nonexistent, in the physical activity and exercise mHealth literature.

An additional gap in mHealth research and general intervention literature pertaining to exercise is the use of responsive exercise prescriptions (i.e., matching a workload to an individual's current mental and physical state). A growing body of research using repeated sampling procedures demonstrates that individuals' affective, physical, cognitive, and contextual states fluctuate over time (e.g., hour to hour, day to day, week to week), which likely impacts decisions to consistently engage in health behaviors (9, 10). Thus, it may be beneficial to allow for some degree of flexibility within an exercise program, such that workloads are assigned in response to the current state of the individual. There exists a framework for responsive programming (Flexible Nonlinear Programming; FNLP) that was developed for competitive sport planning (18). Under this strategy, workloads are first organized on a continuum ranging from low volume/low intensity to high volume/high intensity, and then assigned each day based on each athlete's "readiness to train" (i.e., physical and mental state). To date responsive exercise programming has been used sparingly and under supervised conditions, but results have been favorable regarding fitness outcomes (8, 18, 19).

It is reasonable to speculate that with the near instantaneous ability to share data and communicate using smartphone SMS and Internet capabilities, mHealth messaging regarding daily exercise goals could be modified based on relevant mental and physical states. Due to the aforementioned physical inactivity trends and positive results of mHealth interventions in middle-age adults, the utilization of these participant-responsive strategies may be warranted in their population to increase physical activity levels. However, prior to assessing the efficacy of a responsive exercise intervention delivered via multimedia smartphone messaging in a randomized controlled trial, substantial pre-efficacy testing is required to guide and refine novel protocols (7). In particular, gaining feedback from the perceptions of members of this population regarding these methods, as opposed to a younger generation that grew up with digital technology (i.e., Generation Z), is necessary to guide refinement in later phases of development. Thus, the purpose of the current study is to preliminarily assess the perceptions of middle-age adults regarding multimedia exercise prompts tailored to their current mental and physical states. Because no empirical data exists regarding tailored exercise prompts or the use of multimedia prescriptions, this study is a first exploratory step to gain initial perceptions to these methods. The results will provide direction regarding these factors and allow refinement for future, hypothesis-driven studies involving the methods presented.

METHODS

Participants

Adults residing in the U.S. were invited to complete an anonymous electronic survey that could be accessed via an active link on their smartphone, tablet, or computer. Upon opening the survey link, participants were presented with questions assessing aspects of their immediate physical and mental states designed to gauge their "readiness to exercise" in the moment. Based on their scores to these questions, respondents were provided with a theoretically matched ambulatory

or stretching exercise prompt with a GIF depicting a model engaging in the recommended activity. Instead of being encouraged to complete the bout, the survey then redirected to ask participants for feedback regarding the prompt they received in order to determine their perceptions of the methods.

Prior to recruitment, approval of the protocol was gained by the Institutional Review Board at The University of Tennessee, Knoxville. Inclusion criteria included being between the ages of 30-65 years old and living in the U.S. with access to a computer or other device with internet capabilities. The first page of the survey contained study information (e.g., purpose, expectations, risks, benefits), where individuals were instructed that by completing the survey, they were consenting to participate in the research study. No incentives were provided to respondents to complete the survey.

Protocol

GIF Development: The content of the messages (text instructions, exercise options, filming viewpoints) were determined through a series of meetings with student and faculty research team members. Ambulatory activity (e.g., walking and stepping in place) was chosen as the primary mode because it is an accessible form of activity for a relatively large proportion of adults. The speed of walking bouts were designed to match low (2.0 mph), moderate (3.2 mph), and high intensities (3.5-4 mph) based on information found in the Compendium of Physical Activities (1). The cadence of stepping in place was based on step cadence at each walking speed (90, 110, and 130 bpm). Stretching activities for the lower extremities and lower/upper back were included as restorative activities that are supportive of ambulatory activities. The first author filmed activities in real-time using a default smartphone camera application, using various undergraduate research assistants as models. Videos were then uploaded to Photoshop (Adobe Inc., San Jose, CA) and converted into GIFs, each of which continuously looped every five seconds.

The one-time survey was created using Qualtrics Research Core (Provo, UT) and disseminated using active, links copied to email listservs and Facebook. Upon opening the link, individuals first provided their age and whether or not they lived in the U.S. Those failing to meet the inclusion criteria were thanked for their time and redirected to exit the survey. Eligible individuals were directed to five randomized questions designed to assess immediate exercise readiness. In-the-moment framing was used to gauge respondents' current states regarding emotion, energy, fatigue, physical discomfort, and hydration (e.g. "How energetic are you feeling right now?", "How fatigued are you feeling right now?"). Item ratings were summed, with possible scores ranging from 0 to 40, and score ranges were separated into quartiles such that higher scores indicated higher readiness to exercise.

Based on quartile score, the respondent received one of four possible prompts for walking or stepping in place (quartiles 2-4) or 12 possible stretching prompts targeting lower leg, upper leg, hip, gluteal, lower back, and upper back mobility (quartile 1).

1. Those scoring in the first quartile were assumed to have very low readiness to exercise and were instructed engage in flexibility or range of motion activity.
2. Those who scored in the second quartile were considered to have suboptimal readiness and were provided with a light-intensity, restorative bout of leisurely walking or stepping in place.
3. Those classified in the third quartile were prescribed a bout of walking or stepping at a moderate intensity.
4. Finally, those in the fourth quartile were seen as highly ready to exercise and prompts were designed to challenge an individual to exercise at a moderate intensity for longer periods or to intersperse intervals of very brisk, higher intensity walking.

Each recommended activity was accompanied with a corresponding GIF or set of GIFs depicting the movement of the exercise. Please see the supplemental PowerPoint file to view all animated GIFs and corresponding text prompts for each score quartile. Representative text prompts and GIFs are also provided in Figure 1. Participants were directed to read the text and view the animated GIF while explicitly instructed to abstain from performing any activity for the purpose of this research study.

It is important to note that, while seemingly intuitive and practical, the concept of measuring readiness to inform daily training decisions is a relatively new concept suggested for use in the sport domain. Thus, no empirical data (i.e., means, standard deviations, ranges) currently exists to explicitly classify readiness as high or low. Subsequently, no guidelines have been developed to indicate by how much to adjust intensity or duration based on a change in readiness. As such, the use of quartiles was chosen to represent the three known intensity classifications (low, moderate, high), with a fourth "restorative" quartile considered the lowest, as a preliminary method to classify individuals and provide a mock exercise recommendation.

Next, participants were directed to a series of items designed to assess GIF quality, task self-efficacy (i.e., confidence to perform all movements demonstrated and to perform the activity at the suggested intensity and duration), and forecasted coping self-efficacy (i.e., confidence to perform the suggested intensity and duration when feeling "slightly" or "a lot" better or worse, physically and/or mentally). Participants were then presented with an open-ended response question asking for additional feedback regarding their perceptions of the message they received. Additional questions pertaining to standard demographic data (e.g., race, sex), determining the type of device participants used to complete the survey, and average amount/intensity of exercise participants completed in a week were included at the end of the survey.

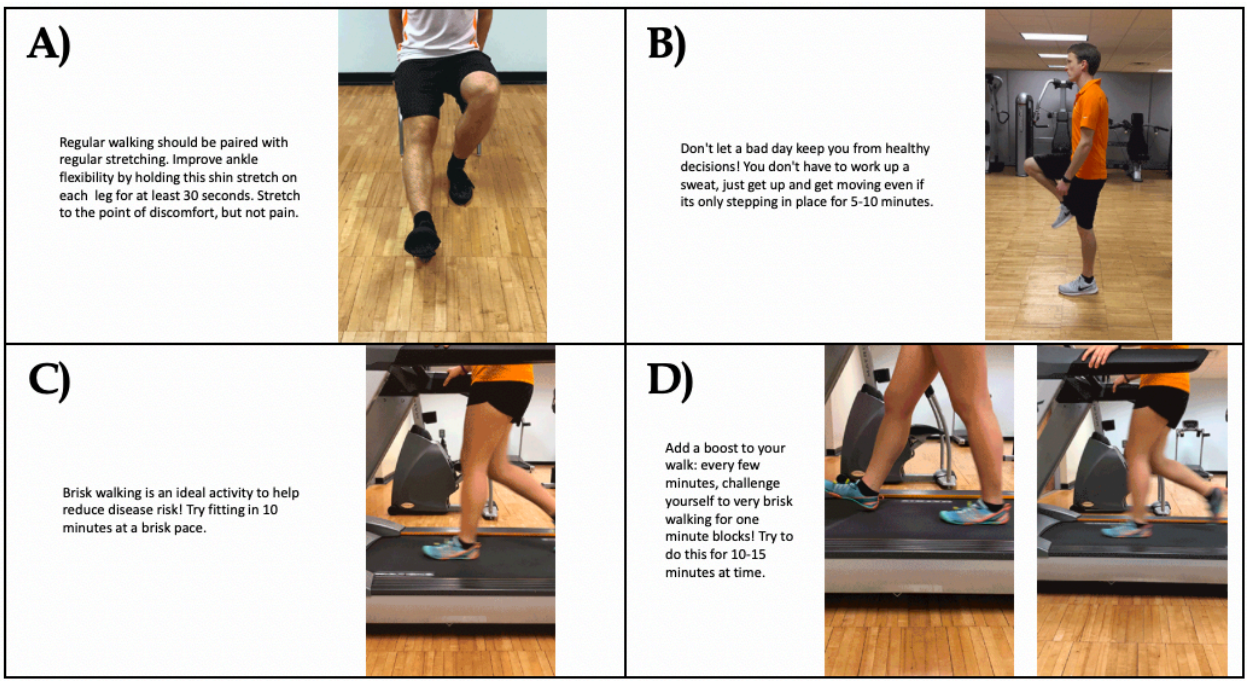

Figure 1. Text prompts and GIFs received by participants. A) Quartile 1 – restorative stretching bouts; Scores 0-10, B) Quartile 2 – light intensity walking (2 mph) or stepping (90 bpm); Scores 11-20, C) Quartile 3 – moderate intensity walking (3.2 mph) or stepping (110 bpm); Scores 21-30, D) Quartile 4 – moderate-to-vigorous intensity walking (3.5-4 mph), stepping (130 bpm), or intervals alternating light and vigorous intensity walking.

Instrumentation: Preliminary Exercise Readiness Assessment: All items were scored on 9-point Likert scales (range 0-8 per item). Using in-the-moment framing, respondents provided ratings regarding five factors, presented in a randomized order:

1. Emotional State (0=most unpleasant imaginable, 2=moderately unpleasant, 4=neutral, 6=moderately pleasant, 8=most pleasant imaginable),
2. Energy Level (0=not at all energetic, 2=slightly energetic, 4=moderately energetic, 6=very energetic, 8=extremely energetic),
3. Physical Discomfort (0=no discomfort, 2=mild discomfort, 4=moderate discomfort, 6=severe discomfort, 8=worst possible discomfort),
4. Hydration (0=not at all thirsty, 2=not very thirsty, 4=neutral, 6=thirsty, 8=very, very thirty),
5. Fatigue (0=not at all fatigued, 2=slightly fatigued, 4=moderately fatigued, 6=very fatigued, 8=extremely fatigued).

Reverse scoring was applied to items regarding discomfort, thirst, and fatigue so that higher summed scores would indicate higher readiness to exercise. These items were based on prior research using exploratory factor analysis (37) and thematic analysis (38) which suggested that energy, fatigue, affective valence, physical discomfort, and hydration factors underly the concept of "readiness to exercise" in college students and adults with obesity. This concept was adapted from "readiness to train" as described for FNLP (18).

GIF Quality: All items were scored on 7-point Likert scales (range 0-6 per item). Participants were presented with three statements designed to assess aspects of GIF quality:

1. "The GIF loaded on my screen in a timely manner."
2. "The GIF is clear."
3. "The activity suggested by the GIF is easy to understand."

Participants then rated their level of agreement to these statements (0=strongly disagree, 1=disagree, 2=somewhat disagree, 3=neither agree not disagree, 4=somewhat agree, 5=agree, 6=strongly agree).

Self-Efficacy: In line with guidelines for constructing self-efficacy scales (41), all items were scored on an 11-point Likert scale (range 0-10 per item; 0=not confident at all, 5=moderately confident, 10=completely confident). One statement pertained to task self-efficacy ("How confident are you that you can perform all of the required movements shown in the image?"). Five statements were then presented designed to gauge forecasted coping self-efficacy:

"How confident are you that you can complete this activity [*suggested intensity and duration*]
1. …in your current state?"
2. …when feeling slightly worse mentally/physically?"
3. …a lot worse physically/mentally?"
4. …slightly better physically/mentally?"
5. …a lot better mentally/physically?"

These items were adapted based on a multidimensional approach to self-efficacy, such that coping self-efficacy is distinct from task self-efficacy (30).

Exercise as a Vital Sign (EVS) Questionnaire: The EVS is designed to identify individuals who are not meeting recommended physical activity levels and assist health care providers in promoting physical activity to such individuals (31). The questionnaire consists of two questions:

1. "On average, how many days per week do you engage in moderate to strenuous exercise (like a brisk walk)?"
2. "On average, how many minutes do you engage in exercise at this level?"

Responses to both questions are then multiplied (# days x minutes reported) to determine the total number of minutes individuals complete moderate to strenuous intensity exercise per week.

Statistical Analysis

All quantitative analyses were conducted using Statistical Package for Social Sciences (SPSS; IBM Corp., Armonk, NY). Descriptive and frequency statistics were conducted to analyze participants' demographic information, the distribution of individuals responses across quartiles at the end of the survey, GIF quality, and task self-efficacy. A one-way ANOVA with a Bonferroni correction was used to compare coping self-efficacy scores. Open-ended responses for messaging feedback were analyzed via the thematic and content analysis method by Braun

and Clark (2005). The first author thematized open-ended responses to the last question of the survey, while the third author provided a secondary analysis to validate initial themes. Initial agreement was 72.1% before additional discussions were held to come to 100% consensus, with the fourth author acting as a tie-breaker when the first and third authors could not come to agreement.

This research was carried out fully in accordance to the ethical standards of the International Journal of Exercise Science (24).

RESULTS

Participant demographics can be found in Table 1. A total of 204 participants completed the survey (81.37% women, 47±10 years). Devices utilized to take the survey included smartphones (49.5%; 64.0% iPhone, 36.0% Android), computers (45.6%), and tablets (4.9%). On average, survey completion took 7±5 min. Across the four readiness quartiles, 1.47% placed in the first quartile, 20.59% placed in the second, 59.31% in the third, and 18.63% in the fourth. GIF quality and self-efficacy scores are reported in Table 2. Significant differences were noted ($F=3.229$, $p<.01$) regarding coping self-efficacy when forecasting differing mental/physical states relative to current state.

Table 1. Participant Demographics

	All (N = 204)
Age (years)	47±10
BMI (kg/m2)	29±6
Mins/Week Exercise	131±115
Women (%)	81.37%
Caucasian (%)	94.12%
College Graduate or Higher (%)	80.39%

Note: All data represent means and standard deviations. Minutes of moderate exercise determined using items from the Exercise as a Vital Sign (EVS) survey (31).

Of 204 participants who completed the survey, 84 (41.2%) answered the final open-ended question asking for feedback regarding the protocol and participants' perceptions of the overall exercise message. No significant differences were noted between those who did and did not provide feedback regarding age (46±10 vs. 47±10; $t=.38$, $p=0.70$), readiness score (25±6 vs. 26±6; $t=.98$, $p=.33$), minutes of exercise per week (134±97 vs. 130±124; $t=-.24$, $p=.82$), BMI (28±6 vs. 29±6; $t=1.67$, $p=0.10$), or proportion of female respondents (82% vs 77%; $\chi^2=0.63$, $p=.43$). The final analysis yielded five themes regarding participants perceptions to the overall methods of the study, depicted in Table 3:

1. Improve Attractiveness, where participants mentioned making some aspect of the protocol more attractive (e.g., environment where exercise was filmed, an aspect of the model performing the activity, and/or fixing typos);
2. Limiting Factors, where participants mentioned not being able to perform the activity recommended due to limitations such as lack of equipment, health concerns, and/or a technical

issue with receiving the prompt that kept them from understanding the exercise recommendation;
3. Exercise Clarification, where participants mentioned needing some aspect of the exercise protocol explained or shown in more detail;
4. Liked/Understandable/Doable, where participants mentioned they would have no problem completing the recommended activity, that the overall message was clear, and/or that they appreciated the methods in which the recommendation was given to them;
5. Disliked/Unwilling, where participants mentioned they would not want to do the recommended activity because they found it elementary, irrelevant, or not reflective of their perceptions.

Table 2. GIF Quality and Self-Efficacy.

GIF loaded timely		5.29±1.18
GIF is clear		5.36±1.11
GIF activity easy to understand		5.43±1.13
Task Self-Efficacy		9.34±1.62
Coping Self-Efficacy - Confidence to perform the activity at its suggested duration/intensity when feeling…		
	A lot worse	5.74±3.14[a]
	Slightly worse	7.43±2.86[b]
	In current state	8.57±2.28[c]
	Slightly Better	8.79±1.98[c]
	A lot better	9.21±1.81[d]

All data represent means and standard deviations. GIF Quality rated on a 7-point Likert Scale (0=Strongly Disagree, 3= Neither Agree nor Disagree, 6=Strongly Agree). Task self-efficacy (i.e., confidence in being able to perform all of the required movements shown in the image) and coping self-efficacy (i.e., confidence in being able to perform the recommended activity when feeling worse/better) rated on an 11-point Likert Scale (0=Not Confident At All, 10=Completely Confident). Statistical significance ($p<0.05$) between coping values is denoted by different letters.

In order to highlight the overlapping nature of participants' responses (i.e., comments that spanned multiple themes), distributions across themes were calculated and are also shown in Table 3.

Table 3. Qualitative Themes.

Themes (% of Responses) and Subthemes	Representative Participant Responses
Theme 1: Improve Attractiveness (49%)	
a) Aesthetics	"The GIFs should be as pleasing to the eye as possible…think light, bright, clean, crisp, color, but simplicity (clean tennis shoes; minimal background distraction; clean, crisp workout clothes…an appealing image overall." (Participant 59)
b) Model	"…the model [does not] need to be the 'ideal physical specimen' -- better if the physical image is more attainable to the average person." (Participant 59)
c) Environment	"A picture of someone walking outside rather than on a treadmill would be more pleasant." (Participant 8)

Theme 2: Limiting Factors (19%)		
a)	External	"Gif didn't load. I have no idea if it was brisk walking or scaling Everest." (Participant 30) "Showing walking on a treadmill only may suggest that that's where you need to walk and it should be done in exercise clothing. Access to both of those may be limited for some...especially when recommending small amounts of time." (Participant 44)
b)	Internal	"This activity might [aggravate] physical problems that already exist, but I am able to walk quite a distance in normal circumstances." (Participant 81)
Theme 3: Exercise Clarification (19%)		"The gif showed only legs, should I be moving my arms, too?" (Participant 11) "You might consider adding the pace or miles. It just said 30 minutes. Was it a leisurely walk or get your heart rate up and how high?" (Participant 15) "You may want to clarify how high the knee or leg should reach. I look at the young man and think: "oooh, he's healthy. Must I lift my leg that high?" "(Participant 42)
Theme 4: Liked/Understandable/Doable (60%)		
a)	Easy to Understand/Do	"I think it is a great activity and now I understand more about that I did. Great Job!" (Participant 5) "Seems like a relatively easy physical activity that is agree would likely improve my mood and definitely would improve my physical wellbeing." (Participant 43)
b)	Liked Study Purpose/Methods	"I appreciate that I cannot tell specifically what your intent is with the image. It strikes me as a truly neutral/unbiased presentation and I had no inclination to couch my answers based on meeting or avoiding a predetermined outcome." (Participant 84)
Theme 5: Disliked/Unwilling (18%)		"The image is corny as is the text. I'm not really a visual person so I'd prefer it just as text without the third grade "keeps the doctor away" stuff." (Participant 29) "The image didn't appear to be what I would consider brisk walking. It seemed more of a moderate pace." (Participant 75) "You asked if I COULD perform and I said yes. You did not ask if I WOULD perform. Now to that I would have said no. :)" (Participant 77)

DISCUSSION

The purpose of this exploratory study was to determine perceptions of multimedia exercise prompts tailored to middle-age adults' current mental and physical states via electronic surveys. The results demonstrate that the GIFs used to convey exercise recommendations were rated high in quality and task self-efficacy was relatively high among respondents across prompted activity types. The differences in coping self-efficacy suggest that fluctuations in mental and physical state hypothetically impact confidence levels to perform a given dose of activity (Table 2). The qualitative analysis of open-ended responses to the survey indicate that while the overall perceptions of the protocol were positive, improvements can still be made regarding its delivery (Table 3).

The use of GIFs to convey exercise messaging is an underutilized, but potentially useful approach for mHealth to help individuals overcome common barriers to exercise. Throughout the literature, perceived time constraints, inclement weather, fatigue, and resource accessibility/cost are often associated with less time spent in physical activity and exercise (2, 15, 32, 39). While our preliminary procedures accounted for low energy levels in determining an appropriate activity prompt, it is possible that individuals may have adequate energy to engage in a 30-minute brisk walk, but may not have access to necessary resources (e.g., fitness centers, exercise professionals, transportation) (39) or be unwilling to walk in the rain. Text instructions with GIFs depicting stepping in place indoors can convey the flexibility of performing similar modes of exercise in one's current location (e.g., home, workplace) and provide guidance on exercise techniques without having to travel to a fitness center or endure inclement weather. In this study, GIFs used to demonstrate exercise movements was a novel aspect viewed positively by participants (Theme 4, Table 3). As stated by Participant 13, "I think the message/GIF is great for the average person…The activity is one that appears to be achievable for a people with a range of fitness levels." This was echoed by Participant 5, "I think it is a great activity and now I understand more about it [than] I did," and Participant 37, "The activity and GIF are perfectly understandable." In line with the desirable qualities mentioned by Bakhshi (2016), participants appreciated the clarity and brevity of the GIFs and expressed how they aided in the understanding of the exercise movements. Participant 17 wrote, "…this was clear and direct. Easy to understand," while Participant 19 stated "I feel everything is to the point and my perceptions about the message are complete." These qualitative data, paired with the high ratings regarding timely downloading, visual clarity, and ease of understanding (5.29-5.43 on a 0-6 Likert scale; Table 2), warrant additional testing of GIFs to improve this form of communication to convey exercise goals.

The ability to measure momentary indices of readiness and then immediately provide a suggested activity using dynamic visuals and clear messaging via smartphone technology represents an innovative approach to intra-individualized exercise prescription. In response to high ratings of fatigue, a tailored GIF and message could be used to convey that exercise does not have to be "all or nothing" and that at times, it may be acceptable or desirable to deviate from a given prescription. Healthy habits can be built in small increments – a lighter intensity or shorter duration that matches an individual's current state reinforces the habit of prioritizing being physically active without perpetuating feelings of failure associated with not meeting daily goals. With that said, a primary goal of mHealth is to promote the attainment of the physical activity recommendations. While allowing day-to-day flexibility warrants further exploration, it would also be important for researchers to consider how personalized prescription can be incorporated while still achieving the recommended weekly dose. For example, an individual consistently indicating low readiness would not engage in sufficient aerobic activity for health benefits, but the ability to monitor this occurrence could allow researchers or practitioners to apply secondary interventions (e.g., sleep, nutrition, injury treatment) based on which readiness factor(s) are consistently low.

An important finding from the current study relates to areas of improvement in the multimedia approach. Substantial pre-efficacy testing is imperative to intervention development and outlined in the Obesity-Related Behavioral Intervention Trials (ORBIT) Model (7). This set of guidelines was designed to streamline the development of long-term health-behavior interventions through multiple phases of iterative and flexible testing (7). While a portion of our participants stated they would not complete the exercise due to disliking the prompt (Theme 5, Table 3), the majority of comments indicated participants had a positive perception of the prompt (Theme 4, Table 3) and/or provided constructive feedback regarding improvement of various aspects of the methods (Themes 1, 2, and 3; Table 3). Many comments reflected improving upon common benefits of GIFs, namely the ability to convey information clearly in a short amount of time and to elicit acute emotional responses (3, 16). As Participant 76 wrote, "Why not make the GIF funny or more motivating in some way? A funny GIF that made me laugh would actually make me MORE likely to do the activity." This was echoed by Participant 40, who mentioned wanting the models performing exercises to be more expressive, "The person in the gif looked bored or maybe frustrated at having to perform the action. I know the point was to demonstrate the specific activity (which it did very well) but watching a bored person isn't encouraging." Other critiques related to improving the written message explaining the exercises depicted in GIFs, such as fixing typos: "There's a grammatical error—"its" instead of "it's"—that was distracting and irritating." (Participant 74). Some participants suggested taking into account limiting factors that would keep them from completing the recommended activity, such as fixing technical problems regarding the GIF, clarifying aspects of the recommended exercise, and lack of appropriate equipment. Several of these comments suggested making the exercises more accessible by taking health problems into consideration, "…knowing why someone is fatigued seems important. Like, it's my bedtime. Someone else might have more serious health problems." (Participant 51). Others mentioned including exercise outside or having models wear something other than exercise clothes to make activities more accessible. Participant 59 stated, "I don't own a treadmill, so I walk outside. Everyone can walk outside; not everyone can walk on a treadmill. Maybe think of using prompting GIFs that everyone can do -- regardless of equipment," while Participant 8 wrote, "…getting dressed in workout clothes and walking on a treadmill doesn't really match with a 10 minute walk (wearing leisure clothes and being outside matches with that message better)." Despite these critiques a large portion of participants stated they appreciated the methods used and would be confident in completing the given exercise, which is reflected in self-efficacy scores. As Participant 49 said, "Instructions were great. Given in a positive manner and related to how I'm feeling-I don't feel like getting out today and relating the exercise to watching TV is a great idea." By addressing the feedback acquired from participants' open-ended responses, these methods can be refined and improved for future intervention use.

Further, regarding refinement, the timing of when GIFs are disseminated to individuals will be critically important to how well these protocols work. Based on the growing evidence that temporal and contextual variance within a person can impact behavioral consistency (9), experts have acknowledged the need for Just-In-Time-Adaptive Interventions (JITAIs). A JITAI design is a method that utilizes both passive and interactive means in order to promote health behavior management in participants, including regular physical activity (6, 17). Participants engage with

a JITAI intervention via mobile phones at times of "heightened vulnerability" (e.g., urges to smoke or binge eat) (23). Once contacted, JITAI operators respond to participants unique and changing needs "by providing the kind of support that is needed, as much as needed, and only when needed" (23). Therefore, sending prompts to measure readiness and provide exercise suggestions would be relatively meaningless if sent during times when people do not want to or cannot exercise (i.e., at work, in class, travelling). One option is for participants to initiate a prompt when they need it (i.e., right before they plan to exercise) in order to log current mental/physical states and receive a recommended activity. Allowing for modifications to the recommended activity may improve the exercise experience. In a previous study (36), higher pre-exercise energy levels predicted more positive in-task affective ratings during moderate-intensity walking, which is important as positive affect predicts future behavior (25). While respondents in the current study were not encouraged to complete the recommended exercise, the aspect of matching workload to feelings "in the moment" was well received. Participant 39 wrote, "I like the idea of receiving text messages with activity suggestions based on mood." After receiving their recommendation, Participant 64 seemed to consider other possibilities of exercises and when they could be completed, commenting, "It's remarkable if you think about it how many slightly physical activities can be done at night simply watching your favorite shows for as little as 15 mins to an hour. I definitely should practice some of these since I'm a truck driver and sit for long times." Some comments reflected results relating to self-efficacy scores. Participant 41 reflected on having high coping self-efficacy as a result of their exercise prescription, "It wouldn't be too hard so with me not feeling very good right now, I would still be able to do it."

This study is not without limitations. The majority of participants consisted of Non-Hispanic Caucasian women, therefore our results likely are not generalizable to the larger middle-age adult population. Differences in population such as age, sex, race, and health status may result in differing perspectives to our methods (e.g., familiarity with GIFs, unrelatable exercise model). Based on the positive feedback received in this study, testing should expand to more diverse populations in the future. Additionally, it should be noted that, because the goal of this study was to explore respondents' perceptions of the methods employed, pertinent information relating to completing the recommended activities, such as health history, current physical activity behavior, and medical contraindications to exercise, were not taken into account. We acknowledge that these factors may have impacted responses to the GIFs, however at this stage of inquiry creating multiple GIFs pertaining to various health statuses was logistically unfeasible. In future interventions utilizing these methods where participants are asked to complete the recommended activities prescribed to them, such information is necessary and should be collected from participants. Moreover, recommended exercises were limited to ambulatory and stretching activities. Based on participant feedback ("Might be helpful to include Optional add-ons like arm motions or higher knees" – Participant 14), other types of activities may be warranted for similar baseline testing and included in future iterations of this study. In particular, stretching activities were prescribed far less (1.47% of respondents) and received far fewer reviews compared to the ambulatory recommendations. While overall feedback regarding the exercise recommendations was positive, current directions for refinement are most applicable to the ambulatory bouts while additional research is needed to

explore understanding and perception of stretching prompts. Furthermore, while the quartiles used to categorize participants provided proof-of-concept, their use is not empirically tested and requires further refinement. It is possible that individuals' perceptions of the assigned exercise bout may have been influenced by the specific quartile they were assigned (i.e., providing negative feedback due to disliking the recommended exercise because it was perceived as too easy or hard), which was based on a single measure of readiness. Multiple assessments over time may serve to improve algorithms for exercise bout recommendations by accounting for increases or decreases in readiness over time, in addition to the absolute score. Finally, while coping self-efficacy was not disentangled in our survey to measure mental and physical states separately, the significant differences found warrant further investigation to parse out these individual effects. By acknowledging these limitations, we now have important information to direct protocol refinement. This is in line with the ORBIT Model (7) regarding flexible, iterative processes to designing novel behavioral interventions without expending valuable resources with premature large-scale control trials.

In conclusion, preliminary results from this study show that the use of electronically delivered multimedia exercise prompts tailored to individuals' current mental and physical states may be a promising method of exercise promotion and warrants further investigation. Despite a lack of empirical evidence in the categorizing strategy utilized in the methods, resulting high self-efficacy scores demonstrates proof-of-concept, warranting future use and further refinement of this strategy before enacting actual behavior change with this approach. Several strengths exist within this study, such as the use of open-ended questions to take into account social validity and utilization of interrater reliability in the analysis of qualitative data, which minimized the risk of bias and increases the trustworthiness and validity of themes found. Based on feedback from participants, considerations to the methods include the inclusion of other types of exercises and environments where activities can be performed, as well as surveillance of disease/illness risk added to the survey. Additionally, trans-disciplinary teams have been recommended to improve the development of interventions (14), and in particular, the delivery of JITAIs (22, 23, 35). As such, the inclusion of professionals outside of the exercise realm (e.g., graphic designers, visual artists) may be included in the future to improve certain aspects of the methods in this study, particularly GIF creation and delivery.

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