Original Article

A randomized controlled trial to assess the effectiveness of a mobile application-based lifestyle change program (FASTer Way) on body composition, biochemical and hematological health markers, body image, and self-esteem in overweight women

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Background: Numerous mobile phone applications have been developed with the goal of producing behavior changes that lead to weight loss and enhanced health. However, the evidence basis for these applications is often lacking, which renders them ineffective for altering health behaviors. Therefore, the purpose of this study was to examine the potential benefits of a novel mobile application, The FASTer Way to Fat Loss® (FW).

Methods: Forty-two overweight, but otherwise healthy women were recruited for this parallel study and randomly assigned to an exercise and nutrition education only control (CON, n=21) or an integrated mobile application group (FW, n=21), which included exercise training and dietary modifications that were overseen by an individually assigned coach. Both groups were assessed at baseline and 6 weeks post-intervention for body composition, blood health indices, and multiple questionnaires for self-esteem and body image. Absolute mean differences within and between groups were measured using unpaired *t*-tests with statistical significance set at P<0.05.

Results: Compared to the CON group (0.56±1.54 kg), the FW group significantly reduced total mass (–1.21±1.82 kg; P=0.002), fat mass (0.42±1.38 *vs.* –1.45±1.23 kg; P<0.001), body fat percentage (0.23%±1.33% *vs.* –1.24%±1.32%; P=0.001), and body mass index (0.24±0.59 *vs.* –0.46±0.60 kg/m^2; P<0.001); whereas no significant between-group differences were detected for lean body mass (P=0.86). Additionally, total cholesterol was significantly reduced in the FW group (–5.2±14.9 mg/dL) compared to the CON group (8.7±22.8 mg/dL; P=0.03). There were no other significant between-group differences in blood lipid profiles, blood health indices, or subjective measures of self-esteem and body image.

Conclusions: An integrated, multifactorial smartphone application (FASTer Way®) elicited positive changes in body composition and total cholesterol in six-weeks. Future research should investigate these effects in other populations to better generalize these results.

Trial Registration: ClinicalTrials.gov NCT05813548.

Keywords: Persuasive system design (PSD); mobile application; body composition; self-esteem; body image

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Introduction

Humans have used various tools to plan, track, and review health behaviors for thousands of years. The earliest examples likely date back to the ancient Greeks, who kept detailed journals of their exercise training and nutrition regimens leading up to each Olympic games (1). Slightly more modern innovations can be dated back to the mid-15th century, with the development of the first pedometer by Leonardo DaVinci (2). In 1964, the Japanese pedometer, manpo-kei, was introduced as an exercise step tracker with a goal of achieving 10,000 steps per day (3). Moreover, this innovation was one of the first tools to provide quantitative guidance and feedback for a health behavior. By the turn of the 21st century, numerous technological advances have reached the market that assist users in tracking, planning, and achieving their fitness goals (4).

In recent years, a multitude of mobile phone applications have been introduced in order to guide and/or influence health behaviors to ultimately enhance physical fitness or assist users in nutritional tracking and weight loss (4). However, the marriage of this technology with evidence-based guidance is an uncommon occurrence on the current smart device application market, which results in many applications being ineffective for instilling health behavior changes and a general lack of consensus regarding the most effective practices (5). For example, a wide number of applications have been developed for health outcomes such as weight loss, however, it is clear from both a scientific and a technological perspective that there is no "one-size-fits-all" approach for weight loss when it comes to exercise or nutrition applications (6). While organizations such as the World Health Organization (WHO) or American College of Sports Medicine (ACSM) provide generalized weight loss guidelines, weight loss is multifactorial and requires personalized modification of numerous health behaviors; no single approach is effective for every individual. Therefore, one's weight loss journey can be highly complex and difficult to navigate without proper direction. While many mobile applications and weight loss programs have become more accessible, the personalization of strategies and individualized guidance is often lacking.

In 2018, data from the National Health and Nutrition Examination Survey (NHNES) showed that 49.1% of US adults had attempted a weight loss program in the previous 12 months. Moreover, nearly 63% of the respondents reported using exercise and energy restrictive eating as methods of inducing weight loss (7). While exercise is an important factor for enhancing physical fitness, improving body composition (8), and maintaining muscle mass during periods of energy restriction (9), it requires a degree of competence to be performed safely and effectively. Additionally, dietary energy restriction is an umbrella term that can be achieved via numerous methods that often substitute simplicity for complexity, which renders the average adult with a limited understanding of these intricacies (10). For these reasons, among others, it is intuitive that previous

Highlight box

Key findings

- This research study reports that users of a persuasive system design (PSD) based smartphone application (FASTer Way) lost significantly more weight and body fat over a 6-week intervention phase compared to a control group that only received general exercise and nutrition guidelines. Moreover, the group following the mobile application exhibited significantly improved blood cholesterol levels.

What is known and what is new?

- The current smartphone application marketplace is flush with mobile applications seeking to assist users in health-related goals such as weight loss, developing an exercise routine, or even following a more nutritious diet. However, the evidence-basis for many of these applications is lacking resulting in unreliable and unpredictable outcomes for users. Currently, it is unclear as to what type of application design and information delivery method are most effective at promoting user engagement, instilling health behavior change, and ultimately eliciting positive health outcomes.
- Currently, it is unknown as to what application features and programmatic frameworks are most effective for instilling health behavior change and driving body composition improvements.

What is the implication, and what should change now?

- This manuscript lends potential credence towards PSD-based health behavior change smartphone applications, but further investigation is needed to fully uncover the most effective interface and user experience for health-related outcomes.

research has shown that around 1/3 of weight loss seekers actually achieve their goals (11). Therefore, it is clear that the advent of health and nutrition technologies still requires the need for individual guidance (12), as well as clear methods for overcoming the intricacies of weight loss.

Since the adoption of adequate weight loss methods often faces obstacles such as insufficient guidance and motivation (13), mobile applications have begun integrating persuasive system designs (PSDs), which are engineered to provide individualized education, guidance, and feedback (14,15). One such of these applications, The FASTER Way to Fat Loss® (FW) is a novel tool that integrates crucial weight loss components—exercise, dietary control, and lifestyle adjustments—into a cohesive PSD. This application provides individualized coaching, bi-weekly at-home exercise routines, daily intermittent fasting guidance, and nutrition recommendations focused on high protein intake. Within the PSD, the application seeks to overcome common barriers to exercise. For example, FW employs at-home fitness regimens since many overweight or obese individuals are hesitant to participate in public fitness regimens (16). The efficacy of at-home exercise routines in reducing barriers to physical activity is well-documented (17), which offers a private and secure environment for regular exercise and overcomes the exercise competency pitfall. Additionally, the application promotes techniques like intermittent fasting and carbohydrate cycling, which are noted for their ease in creating energy deficits (18), thus, enhancing the impact of dietary modifications. By combining these applicable routines with evidence-based practices, such as professional guidance and motivational feedback (19,20), this mobile application technology emerges as a promising tool for improving weight loss outcomes. Nonetheless, the true efficacy of this evidence-based mobile application remains to be verified through rigorous scientific testing across various populations.

Therefore, the purpose of this study was to assess the efficacy of a multi-component nutrition and exercise mobile application compared to general health and exercise guidelines for weight loss outcomes. We hypothesized that subjects following the integrated mobile phone application would experience superior outcomes in body composition and weight loss compared to subjects only receiving general exercise and nutrition guidelines. We present this article in accordance with the CONSORT reporting checklist (available at https://mhealth.amegroups.com/article/view/10.21037/mhealth-24-62/rc).

Methods

Subject recruitment

This study was approved by an institutional review board (IRB) of Advarra (registration No. 00000971) with the protocol number Pro00069566, and conducted in accordance with the Declaration of Helsinki (as revised in 2013). Electronic informed consent was collected for all subjects prior to enrolling in the study. Forty-two healthy women were recruited for the study using an established electronic database. The following inclusion criteria applied to study participants: women between the ages of 30 and 55 years, a body mass index (BMI) between 25 and 35 kg/m^2, and self-reported levels of minimal exercise (≤1 day per week). Exclusion criteria included: exercise >1 day a week, significant food allergies or dietary restrictions, excess alcohol consumption (>7 drinks per week), pregnancy, breastfeeding within the last 3 months, and/or a history of cardiovascular, neurological, metabolic, musculoskeletal, renal, pulmonary, hepatic, autoimmune, or endocrine disease.

A total of 42 women met the minimum required inclusion criteria for participation. All 42 women were enrolled for participation in the study. Twenty-one women were randomly assigned to the control (CON) group and 21 women were randomly assigned to the FASTer Way (FW) group. Randomization was performed after baseline testing by stratifying subjects into BMI quartiles, and subjects from each quartile were then randomly assigned to either the CON or FW group using an online software (randomizer.org, Randomness and Integrity Services Ltd.; Dublin, Ireland). Twenty-one women completed and were analyzed in CON whereas 19 women assigned to FW completed the study. There were a total of two dropouts in the FW group due to a loss of communication with both participants.

Study design

This study was a parallel non-blinded randomized controlled trial with an allocation ratio of 1:1. Baseline testing first required subjects to donate blood for analysis before arriving at the laboratory. Once the subjects reached the laboratory, they began the remainder of their baseline testing. This involved a battery of assessments that measured multiple markers of health and performance, including the primary endpoints: body composition, body mass, fat mass, and lean mass as well as performance in the isometric mid-thigh pull (IMTP). Subjective secondary measures, including the Body Image Acceptance and Action

Questionnaire (BI-AAQ), the Body Shape Questionnaire-34 (BSQ-34), and the Rosenberg Self-Esteem Scale (RSE) were also administered. Following baseline testing, subjects were randomly enrolled into either the CON or FW group. Upon enrollment into the study, the participants in the CON group were provided physical and dietary guidelines from the American Heart Association and US Department of Agriculture, respectively, to follow over the duration of the study. The participants attended an educational session with research staff and were instructed on the guidelines provided and were given subject-facing material for reference. These participants were asked to follow these guidelines for six weeks on their own, with no further guidance provided.

The participants in the FW group were given access to the FW app for a duration of six weeks. The application-based health behavior change program offered education and guidance on various lifestyle habits that aid in weight loss and healthy behavior practices. Specifically, subjects were sent notifications from the application in regard to multiple activity, healthy living, and nutrition methodologies. These notifications served to encourage participants to track exercise sessions, follow specific dietary fasting windows each day, and to select recommended proportions of protein, fat, and carbohydrates for each meal. Participants were also assigned a personal coach who monitored their daily progress and served as a point of communication for the participant for the six-week duration.

Blood sampling

At baseline and week 6, participants were asked to fast for at least 10 hours prior to undergoing a blood draw. Venous blood was extracted via standard sterile venipuncture of the antecubital vein by a certified phlebotomist using a 21-gauge (G) syringe. The phlebotomist collected blood into two vials: (I) an 8.5 mL gel-barrier, marble top tube interiorly coated with silicone (BD Vacutainer®, SST™, Becton, Dickinson and Company, Franklin Lakes, NJ, USA) and (II) a 5 mL lavender top ethylenediaminetetraacetic acid (EDTA) vacutainer tube (BD Vacutainer®, Becton, Dickinson and Company, Franklin Lakes, NJ, USA). Following collection, the gel-barrier tubes were inverted several times and allowed to clot for approximately 30 minutes at 4 ℃. Gel-barrier tubes were then placed in a centrifuge and spun at 1,665 G for 15 min at 4 ℃ and the resulting serum samples were aliquoted and stored at –80 ℃ until comprehensive metabolic panel (CMP and blood lipid analyses took place. Serum samples were thawed once and analyzed in the same assay for each analysis to avoid variance. Whole blood samples were collected into the lavender top EDTA vacutainers tubes and were inverted several times, stored at 4 ℃, and analyzed within 72 hours of collection for a standard complete blood count (CBC) analysis. All samples were sent to a local laboratory (Laboratory Corporation of America Holdings, Burlington, NC, USA) for analysis. For the blood markers, 18 participants are reported for the FW group as the specimens for one participant were not analyzed due to improper storage.

Body composition

Following an overnight fast of at least 10 hours, each participant's body weight was measured to the nearest 0.1 kg using a digital scale (Seca, Chino, CA, USA) and their height was verbally reported. Body composition was determined by a whole-body dual-energy X-ray absorptiometry (DXA) (Horizon A DXA System, Hologic Inc., Marlborough, MA, USA) scan. Each assessment was performed by a certified technician, and the digital segmentation was determined via the device's associated software package. Total mass, lean mass, fat mass, and body fat percentage were reported for each subject. Participants were asked to wear comfortable clothing and to remove any items that could interfere with device operation (this could be jewelry, items containing wire, shoes, etc.). Additionally, participants were asked to lie in a supine position with knees and elbows extended and instructed not to move for the entire duration of the scan (approximately 3 minutes). Calibration of the densitometer on the DXA device was done against a phantom device provided by the manufacturing company prior to all testing.

Maximal isometric strength

Each participant was tested at baseline and week 6 for maximal isometric strength using an IMTP device performed in an Olympic style half rack. Participants were secured to the bar using lifting straps and athletic tape to ensure grip was not a limiting factor. Utilizing a pronated clean grip, participants were instructed to assume an athletic body position. Knee angle was confirmed between 125°–135° using a hand-held goniometer and hip angle was controlled at approximately 175°. Strips of athletic tape with measurements were placed in a coordinate plane to maintain consistent foot spacing. Once body positioning was stabilized and recorded, the participant was given a

Table 1 Participant demographic data

Variable	Baseline characteristics (n=40)		P value (*t*-test)
	FW (n=19)	Control (n=21)	
Age (years)	46.0±5.8	41.8±6.7*	0.04
Height (m)	1.64±0.07	1.64±0.05	>0.99
Body weight (kg)	81.9±18.3	78.8±11.0	0.51
BMI (kg/m^2)	29.8±5.1	28.9±3.6	0.51

Data are reported as mean ± standard deviation. *, significantly different (P<0.05) between groups. BMI, body mass index; FW, FASTer Way.

verbal countdown before initiation of their pull. Participants were instructed to maintain minimal tension on the IMTP device chain to eliminate slack prior to initiation of the test. Each participant performed two warm reps, one at 50% and one at 75% of perceived maximum effort. Thereafter, participants completed 2 maximal attempts separated by 2–3 minutes rest. Participants were instructed to use a maximal intent and were given strong verbal encouragement during the assessment. Maximal isometric force was collected using a previously validated linear position transducer (21).

BI-AAQ

The BI-AAQ is a twelve-item self-reported instrument designed to assess body image flexibility, which refers to the ability to accept and experience thoughts, beliefs, perceptions, and feelings about one's body. Questionnaire responses are rated on a seven-point Likert scale from 1 (never true) to 7 (always true). Individual responses are reverse-scored and summed to create an aggregate score. A higher aggregate score indicates greater body image flexibility. The validity and reliability of BI-AAQ has been previously reported in study populations (22). In this study, all twelve items were summed for a cumulative score of 12–84 arbitrary units (au).

BSQ-34

The BSQ-34 is a 34-item questionnaire designed to assess how individuals feel about their appearance. Questionnaire responses are scored on a score from 1 (never) to 6 (always). The BSQ-34 covers feelings of insecurity, embarrassment, desire to self-harm, and eating disorder behavior. A lower score indicates a higher level of confidence about one's body image. The BSQ-34 has been validated for use in clinical populations (23). In this study, all thirty-six items were summed for a cumulative score of 34 to 204 au.

RSE

The RSE is a ten-item scale that measures global self-worth by measuring positive and negative feelings about oneself. All items are answered using a 4-point Likert scale consisting of "strongly disagree", "disagree", "agree", and "strongly agree". Five of the questions are reverse-scored and all ten items are summed. Higher scores indicate higher self-esteem. The RSE has been validated for use in study populations (24). In this study, all ten items were summed for a cumulative score of 10 to 40 au.

Statistical analysis

The absolute mean difference (week 6 – baseline) was calculated for all study variables and compared between groups with a two-tailed, unpaired *t*-test. In the event that the raw data for a given study variable violated normality, a nonparametric Mann-Whitney *U* test was deployed. Statistical significance was determined *a priori* at P<0.05. Percent change was determined from the group's mean value using the following formula: (baseline – week 6)/baseline *100. Finally, between-group effect sizes for body composition were calculated using Cohen's *d* and were interpreted as trivial (0–0.2), small (0.21–0.5), moderate (0.51–0.8), and large (0.8+) (25). All data are reported as mean ± standard deviation (SD).

Results

Participants

Baseline demographic data for the CON and FW groups are shown in *Table 1*. No significant differences were present between groups at baseline other than age (P=0.04). This difference was created due to the two dropouts in the FW group, which increased the group average age from 45.2±6.2 to 46.0±5.8 years (this changed between groups P value from P=0.10 to P=0.041). A CONSORT flow diagram (*Figure 1*) is also provided.

Body composition

Compared to the CON group, the FW group significantly reduced total mass (P=0.002), fat mass (P<0.001), body fat

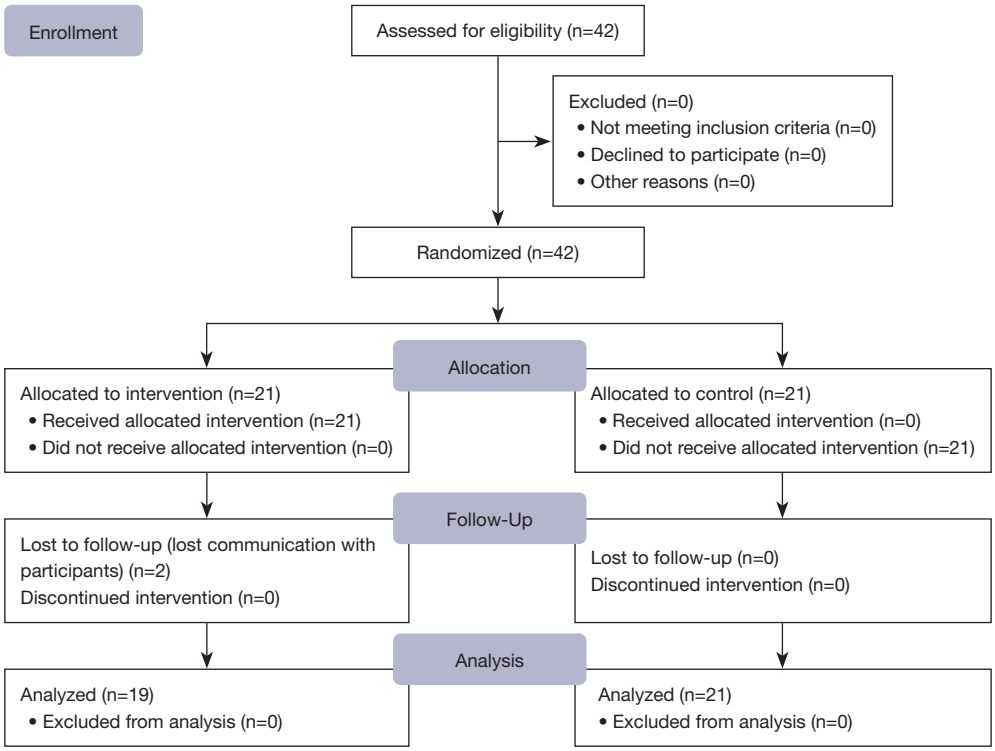

Figure 1 CONSORT flow diagram.

percentage (P=0.001), and BMI (P<0.001). No significant between-group differences were detected for lean body mass (P=0.86). Large effect sizes were found for all variables except for lean body mass, which exhibited a trivial effect size. These results are reported in *Table 2* and displayed in *Figure 2*.

Blood lipid panel

Total cholesterol was significantly reduced in the FW group compared to the CON group (P=0.03). There were no other significant between-group differences in blood lipid profiles. These results are shown in *Table 3* and *Figure 3*.

CBC

Compared to the CON group, the FW group demonstrated a significant reduction in platelet count (P<0.001). No other significant differences were detected for variables on the CBC (*Table 4*).

CMP

There were no significant effects detected for any variable on the CMP (P>0.05). CMP data for both groups are reported in *Table 5*.

Questionnaires

No significant effects were detected for questionnaires assessing body image acceptance, body shape, self-esteem, or estimated exercising aerobic capacity (VO_2) (P>0.05, *Table 6*).

Maximal isometric strength

There were no significant between-group differences at baseline (FW: 90.3±25.4 kg *vs.* CON: 80.1±19.5 kg; P=0.16) or at week 6 (FW: 88.2±25.3 kg *vs.* CON: 81±21.7 kg; P=0.33). Moreover, there were no differences between groups in regard to relative change in IMTP throughout the 6 weeks (FW: –2.32% *vs.* CON: 1.37%; P=0.44).

Discussion

Validation of the effectiveness of health-related mobile applications is an important step in the future of health

Table 2 Body composition

Variable	FW (n=19)			Control (n=21)			ΔFW *vs.* Δcontrol	ΔFW *vs.* Δcontrol
	Baseline	Week 6	Δ Mean, % change	Baseline	Week 6	Δ Mean, % change	P value (*t*-test)	Effect size
Fat mass (kg)	33.63±10.80	32.18±11.07	−1.45, −4.31%	32.06±7.61	32.48±8.00	0.42, 1.31%	<0.001*	1.42
Lean mass (kg)	46.02±8.19	46.25±8.65	0.23, 0.5%	44.50±4.37	44.66±4.54	0.16, 0.35%	0.86	0.037
Total mass (kg)	81.94±18.33	80.74±19.06	−1.2, −1.47%	78.83±10.99	79.40±11.23	0.57, 0.72%	0.002*	1.05
Body fat (%)	40.43±4.86	39.19±5.05	−1.24, −3.07%	40.21±4.57	40.44±4.87	0.23, 0.57%	0.001*	1.35
BMI (kg/m^2)	29.78±5.13	29.32±5.43	−0.46, −1.55%	28.81±3.63	29.05±3.72	0.24, 0.83%	<0.001*	0.97

Data are reported as mean ± standard deviation. *, significantly different (P<0.05) from the control group. Δ = week 6 – baseline. BMI, body mass index; FW, FASTer Way.

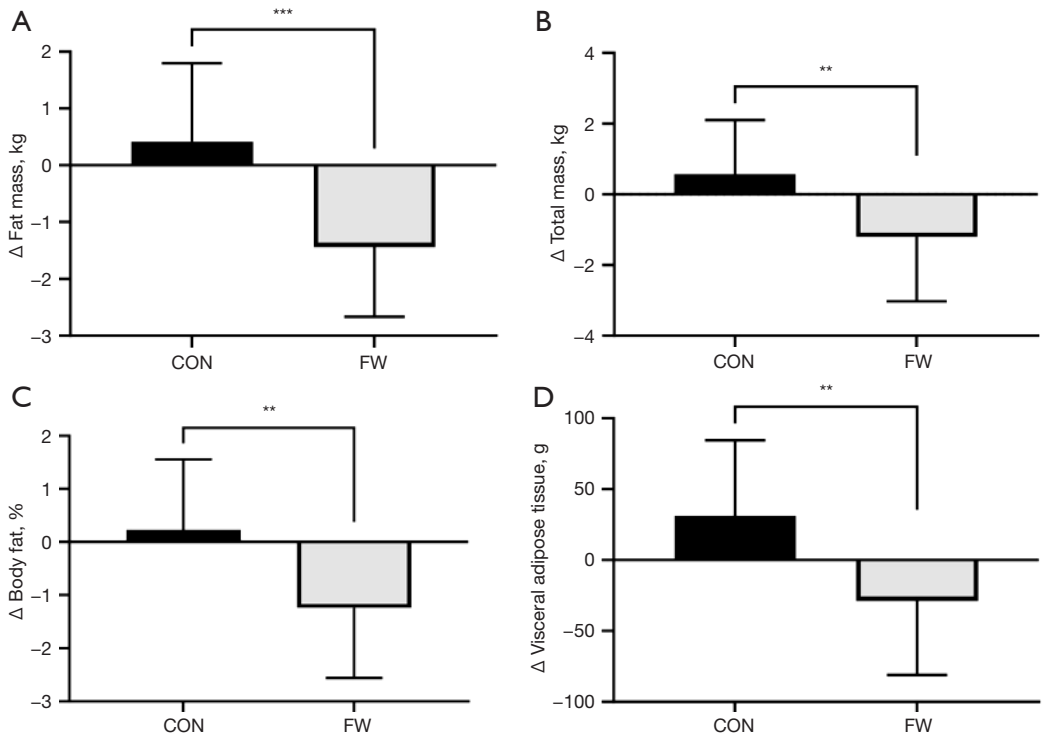

Figure 2 Body composition. Significant body composition results: (A) fat mass; (B) total mass; (C) body fat; (D) visceral adipose tissue. **, significantly different (P<0.01); ***, significantly different (P<0.001). Δ = week 6 – baseline. CON, control group; FW, FASTer Way group.

behavior change technologies. In this study, it was found that the FW group exhibited significantly greater decrements in fat mass and total body mass relative to the CON group. Importantly, lean mass was maintained in both groups suggesting that the weight loss in the FW group was effectively targeted towards adipose tissue. Moreover, the FW group displayed a significantly greater reduction in total cholesterol compared to the CON group. This finding is potentially related to the reduction in fat mass in the FW group (26,27) but could also be linked to an increase in physical activity (28). Nevertheless, our findings indicate that the use of an integrated health behavior change smartphone application (FASTer Way®) elicited improvements in body composition and total cholesterol

Table 3 Lipid panel

Variable	FW (n=19)			Control (n=21)			ΔFW *vs.* Δcontrol
	Baseline	Week 6	Δ Mean, % change	Baseline	Week 6	Δ Mean, % change	P value (*t*-test)
Triglycerides (mg/dL)	88.2±35.6	88.7±36.6	0.5, 0.57%	109.7±69.6	115.7±67.2	6±5.51%	0.58
Total cholesterol (mg/dL)	180.2±32.7	175±31.5	–5.2, –2.9%	194±33.2	202.7±40	8.7, 4.49%	0.03*
HDL-C (mg/dL)	64.3±18.5	63.8±19.6	–0.5, –0.78%	62.7±15.3	66.3±13.6	3.6, 5.77%	0.11
LDL-C (mg/dL)	99.8±26.8	95.1±26.3	–4.7, –4.73%	111.4±27.1	115.6±32.6	4.2, 3.76%	0.07
Chol/HDL-C	2.96±0.8	2.92±0.82	–0.04, –1.35%	3.27±1.02	3.18±0.92	–0.09, –2.75%	0.67
ApoB (mg/dL)	69±17.7	68.6±14.3	–0.4, –0.56%	79.2±18.4	76.1±20.9	–3.1, –3.91%	0.41
CRP (mg/L)	2.7±2.1	2.9±3.5	0.2, 7.49%	2.3±1.7	2.5±2.5	0.2, 8.7%	0.97

Data are reported as mean ± standard deviation. *, significantly different (P<0.05) from the control group. Δ = week 6 – baseline. ApoB, apolipoprotein B; Chol/HDL-C, the ratio of total cholesterol to HDL-C; CRP, C-reactive protein; FW, FASTer Way; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol.

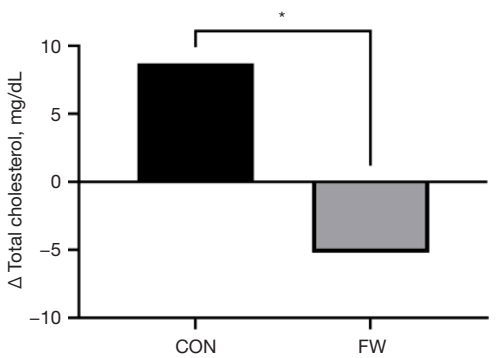

Figure 3 Total cholesterol. Significant total cholesterol results. *, significantly different (P<0.05). Δ = week 6 – baseline. CON, control group; FW, FASTer Way group.

compared to a CON group following traditional dietary and exercise guidelines without professional guidance. Curiously, blood analysis did detect a significant reduction in platelet count in the FW group following the six-week intervention. However, these results may not be clinically significant as the group mean values are still within the reference range of 150 to 450 $\times 10^9$/μL for platelet counts (29). Moreover, a recent analysis has suggested that even moderate exercise can significantly decrease blood platelet counts. Importantly, the typical cardiovascular adaptations to exercise generally enhance blood flow which likely helps maintain function of the coagulation system (30).

Reducing body adiposity requires a multitude of strategies that shift energy balance to a daily deficit. Ideally, this daily deficit reflects a negative fat balance, thus imposing reductions in body fat mass, rather than lean mass (31). This distinction is crucial for numerous facets of health, as decrements in lean mass can reduce resting metabolism (32), decrease bone mass (33), and impair exercise performance and capacity (9). In order to create an internal environment that is primed to reduce adiposity and not lean mass, dieters have to adopt specific strategies to target fat balance and minimize protein breakdown. Methods such as following a high protein diet (34) and performing exercise training (9) are both recognized routes of directing the effects of energy restriction, but each pathway requires at least some level of proficiency in order to be applied in daily life. Therefore, supervised weight loss programs are commonly reported to be more effective at eliciting positive changes in body composition relative to unsupervised programs (35). Not only are unique dietary and activity-based lifestyle modifications necessary, but guidance and feedback are also paramount to successful weight loss campaigns.

Ultimately, the adoption of lifestyle changes is likely more important than the changes themselves in regard to weight loss. For example, employing an energy deficient diet for a single day would do little for bolstering weight loss; the continual application of daily habits is required to produce significant changes in body composition. Essentially, progress towards a weight loss goal would stagnate if an individual were to lose motivation. Thus, novel technologies may be key in ensuring that behavioral changes are both sustainable and adherable in order to elicit desirable changes in body

Table 4 Complete blood count

Variable	FW (n=19)			Control (n=21)			ΔFW *vs.* Δcontrol
	Baseline	Week 6	Δ Mean, % change	Baseline	Week 6	Δ Mean, % change	P value (*t*-test)
WBC (10^3/μL)	6.1±1.6	5.6±1.4	–0.6, –10.04%	6.2±2.2	6.1±1.4	–0.1, –2.23%	0.33
RBC (10^6/μL)	4.5±0.3	4.5±0.3	0, 0%	4.5±0.3	4.5±0.3	0, 0%	0.66
Hemoglobin (g/dL)	13.2±1.1	13.3±1.3	0.1, 0.76%	13.3±1.3	13.1±1.2	–0.2, –1.18%	0.27
Hematocrit (%)	41.8±2.8	43.4±3.5	1.6, 3.83%	41.9±3.8	42.1±3.4	0.2, 0.47%	0.18
MCV (fL)	92.4±6.4	96.4±5.6	4.0, 4.3%	92.4±7.3	93.9±5.8	1.5, 1.6%	0.09
MCH (pg)	29.4±2.3	29.6±2.6	0.2, 0.7%	29.3±2.2	29.3±2.3	0, 0%	0.43
MCHC (g/dL)	31.8±1.5	30.7±1.5	–1.1, –3.52%	31.7±1.7	31.2±1.6	–0.5, 1.5%	0.19
RDW (%)	13.4±0.8	13.8±0.9	0.3, 2.36%	13.7±1.0	13.7±0.9	0, 0%	0.21
Platelet count (10^9/μL)	259.8±57	213±54	–46.8, –18.03%	263.3±61.1	259.6±77.5	–3.7, –1.41%	<0.001*

Data are reported as mean ± standard deviation. *, significantly different (P<0.05) from the control group. Δ = week 6 – baseline. FW, FASTer Way; MCH, mean corpuscular hemoglobin; MCHC, mean corpuscular hemoglobin concentration; MCV, mean corpuscular volume; RBC, red blood cell; RDW, red blood cell distribution width; WBC, white blood cell.

Table 5 Comprehensive metabolic panel

Variable	FW (n=18)			Control (n=21)			ΔFW *vs.* Δcontrol
	Baseline	Week 6	Δ Mean, % change	Baseline	Week 6	Δ Mean, % change	P value (*t*-test)
Glucose (mg/dL)	88±9.5	88.1±9.3	0.1, 0.06%	89.8±9.8	88±7.9	–1.8, –2.01%	0.49
BUN (mg/dL)	14.7±2.8	14.6±4	–0.1, –1.13%	13.1±3.8	12.1±3.9	–1, –7.27%	0.45
Creatine (mg/dL)	0.8±0.1	0.8±0.1	0, 0%	0.8±0.1	0.8±0.1	0, 0%	0.17
Sodium (mmol/L)	141.5±1.8	141.4±2.4	–0.1, –0.04%	141.6±2.0	140.8±2.2	–0.8, –0.57%	0.28
Potassium (mmol/L)	4.4±0.3	4.4±0.4	0, 0%	4.5±0.3	4.5±0.3	0, 0%	0.80
Chloride (mmol/L)	105.7±2.2	106.2±2.1	0.6, 0.5%	106.5±2.2	105.5±2.0	–1.0, –0.89%	0.12
CO_2 (mmol/L)	26.9±3.3	26.3±1.5	–0.6, –2.27%	26.6±2.4	26.6±2.1	0, 0%	0.53
Calcium (mg/dL)	9.3±0.5	9.4±0.4	0.1, 0.66%	9.2±0.5	9.2±0.4	0, 0%	0.33
Total protein (g/dL)	7.1±0.3	7±0.4	–0.1, –1.5%	7±0.3	7±0.3	0, 0%	0.49
Albumin (g/dL)	4.4±0.2	4.3±0.3	0.1, –1%	4.4±0.2	4.3±0.2	–0.1, –2.49%	0.34
Globulin (g/dL)	2.7±0.3	2.7±0.2	0, 0%	2.6±0.3	2.7±0.3	0.1, 2.93%	0.056
Total bilirubin (mg/dL)	0.5±0.2	0.6±0.2	0.1, 18.95%	0.5±0.2	0.5±0.3	0, 0%	0.69
Alkaline phosphatase (U/L)	65.4±16.3	62.9±14.1	–2.5, –3.82%	71.1±20.5	71.1±19.2	0, 0%	0.30
ALT (U/L)	16.7±5.5	20.6±9.3	3.9, 23.26%	21.0±16.1	22.9±18.6	1.9, 9.05%	0.73
AST (U/L)	18.3±3.7	19.6±4.6	1.3, 7.09%	18.8±6.5	20.8±9.6	2.0, 10.63%	0.76
A/G ratio (au)	1.6±0.2	1.6±0.2	0, 0%	1.7±0.2	1.6±0.2	–0.1, –5.79%	0.10
BUN/creatine ratio (au)	18.3±3.1	17.5±4.7	–0.8, –4.2%	16.2±4.9	15.2±4.8	1.0, 6.19%	0.82
GFR (mL/min)	85.7±16.1	79.9±10	–5.8, –6.74%	88.5±18.3	89.9±20.3	1.4, 1.56%	0.05

Data are reported as mean ± standard deviation. Δ = week 6 – baseline. A/G, albumin/globulin; ALT, alanine transaminase; AST, aspartate transaminase; au, arbitrary unit; BUN, blood urea nitrogen; FW, FASTer Way; GFR, glomerular filtration rate.

Table 6 Study questionnaire responses

Variable	FW (n=19)			Control (n=21)			ΔFW *vs.* Δcontrol
	Baseline	Week 6	Δ Mean, % change	Baseline	Week 6	Δ Mean, % change	P value (*t*-test)
BI-AAQ (au)	33.6±13.3	26.5±12.8	−7.1, −21.13%	41±11.8	36±16.3	−5, −12.2%	0.50
BSQ-34 (au)	101.5±22.8	81.4±24.7	−20.1, −19.81%	105±23.1	92.3±25.7	−12.7, −12.10%	0.13
RSE (au)	31.4±4.8	33.6±4.0	2.2, 7.04%	32±4.3	32.3±5	0.3, 0.94%	0.14

Data are reported as mean ± standard deviation. Δ = week 6 − baseline. au, arbitrary unit; BI-AAQ, Body Image-Acceptance and Action Questionnaire; BSQ-34, Body Shape Questionnaire; FW, FASTer Way; GH/AQHH; RSE, Rosenberg Self-Esteem Scale.

composition (14). Since the smartphone application market is heavily saturated with weight loss programs, it is evident that a continuum of effectiveness likely exists where some approaches are more beneficial than others. Applications that integrate multiple avenues of weight loss efforts are likely to be more effective than a single approach (36). Moreover, programs that provide individualized supervision and professional recommendations are also likely to better promote health behavior changes than applications with no guidance component (12,37,38).

Due to these reports of individualized success, PSD principles have become more common in weight loss applications in order to provide tailored feedback and even reward systems, which are all related to long-term weight loss success (14,15). PSD is a form of persuasive technology that entails four unique categories of persuasion: primary task support, dialogue support, system credibility support, and social support (39). Each category provides specific action items or guidelines that lead the user towards the desired behavior change goal. The combination of these principles with an appropriate behavior change theory is likely at the core of generating sustainable weight loss, especially in electronic health (eHealth) formats (40). However, it is unclear as to what combination of strategies is optimal for weight loss technologies which represents an intriguing area of future research (40,41). Given our results reported here, it is clear that a PSD-based electronic intervention (FW) is more effective at inducing short term changes in body composition compared to a control group, but future research may better serve the eHealth marketplace by comparing multiple health technology formats.

Limitations

While our study does show significant differences between the FW and CON groups in regard to numerous body composition outcomes, it is important to highlight that these results are specifically limited to overweight (but otherwise healthy) middle-aged women performing the health and performance tasks in this specific study. It is unclear whether lean individuals, older adults, or even men would experience the same outcomes and it is also uncertain if different performance measures, such as grip strength or jump height, would uncover further differences. Furthermore, our results are limited to a 6-week adoption period. It is well-understood that long-term weight loss programs may require more effort and lifestyle modifications (42) which can influence the efficacy of the program over time. One final potential limitation is that we did not control for participants' individual menstrual cycles and, thus, could have collected body composition data during different phases of the menstrual cycle for some subjects. While not ideal, both the control and experimental group were assessed using the same methodologies, so we do not anticipate significant changes to the outcomes reported in this paper. Future research should investigate long-term health behavior change and weight loss outcomes to truly identify the most effective components of health-related smartphone technologies. Specific factors, such as notification intervals, feedback vernacular, and educational components must be further investigated for their individual contributions to health behavior changes to allow for more effective application design in the future. Finally, as with most exercise-related studies (43), our subject population is not considerably robust (N=40) which limits the breadth of our findings.

Conclusions

Based on our findings reported here, a multifactorial, integrated smartphone application (FASTer Way®) is effective at promoting decrements in body mass, body fat,

body fat percentage, BMI, and total cholesterol relative to a solely education program. Importantly, these results were seen after just six-weeks of adherence. Future research should strive to uncover the intricate details of smartphone applications that lead to the greatest health outcomes and alterations in health behaviors. Given the heavy integration of technology in today's society, this step is crucial for expanding the adoption of healthy habits and improving overall health.

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Footnote

Reporting Checklist: The authors have completed the CONSORT reporting checklist. Available at https://mhealth.amegroups.com/article/view/10.21037/mhealth-24-62/rc

Trial Protocol: Available at https://mhealth.amegroups.com/article/view/10.21037/mhealth-24-62/tp

Data Sharing Statement: Available at https://mhealth.amegroups.com/article/view/10.21037/mhealth-24-62/dss

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. This study was approved by an institutional review board (IRB) of Advarra (registration No. 00000971) with the protocol number Pro00069566, and conducted in accordance with the Declaration of Helsinki (as revised in 2013). Electronic informed consent was collected for all subjects prior to enrolling in the study.

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