International Journal of EXERCISE SCIENCE

Original Research

A Prospective Study Comparing Distance-based vs. Time-based Exercise Prescriptions of Walking and Running in Previously Sedentary Overweight Adults

CODY E. MORRIS†‡[1], JOHN C. GARNER‡[2], SCOTT G. OWENS‡[3], MELINDA W. VALLIANT‡[4], HUNTER DEBUSK†[5], and MARK LOFTIN‡[3]

[1]School of Kinesiology, Recreation & Sport, Western Kentucky University, Bowling Green, KY, USA; [2]Department of Kinesiology and Health Promotion, Troy University, Troy, AL, USA; [3]Department of Health, Exercise Science and Recreation Management, The University of Mississippi, University, MS, USA; [4]Department of Nutrition and Hospitality Management, The University of Mississippi, University, MS, USA; [5]Department of Industrial & Systems Engineering, Mississippi State University, Mississippi State, MS, USA

†Denotes graduate student author, ‡Denotes professional author

ABSTRACT

International Journal of Exercise Science 10(5): 782-797, 2017. Prior work has reported that the declines observed in body mass index (BMI) and circumference measurements in their cross-sectional data were twice as large when calculated from distance energy expenditure estimations compared to energy expenditure estimations based on time and intensity. The primary purpose of this study was to compare walking/running for distance to walking/running for time as part of an exercise intervention. This study followed a between-subjects, repeated measures design. Fifteen overweight, but otherwise healthy participants completed the study. The time-based group walked/ran for self-reported time while the distance-based group walked/ran for self-reported distance. A mixed-factor repeated-measures ANOVA was used to compare all dependent variables both within-subjects and between-subjects. Weekly adherence rates to the exercise program did not exhibit a significant difference ($p > 0.05$). Significant interactions were shown for mean body mass loss between groups as well as mean blood glucose level ($p < 0.05$). Distance-based group exhibited a decline in body mass and blood glucose while the time-based group exhibited an increase in both variables. To the best of the authors' knowledge, the present study is the first to directly compare a distance-based vs. a time-based exercise program for walking and running for improvement of risk factors of cardiovascular disease. The results of this study would suggest that a distance-based exercise prescription of walking or running should provide a clinician or researcher with a closer estimation of overall accumulated exercise and resultant weight loss.

KEY WORDS: Obesity, energy expenditure, physical activity

INTRODUCTION

Cardiovascular disease (CVD) and coronary artery disease together are the leading causes of early death in developed societies (2). There are a number of risk factors associated with an increased risk for developing CVD and they include but are not limited to: hyperlipidemia, hypertension, poor diet, sedentary lifestyle, and excess body fat or obesity (1). One of the most important and common tactics used in any intervention aimed at improving risk factors for CVD is an exercise regimen aimed at weight loss. Traditionally, these exercise regimens have been prescribed as an accumulation of minutes per day or per week (1). While knowing amount of time spent exercising will certainly aid in estimating the amount of exercise actually completed, the knowledge of exercise duration doesn't always contain all of the necessary information. If time spent exercising is the main component prescribed, then a number of other factors must be considered, including intensity of exercise.

Williams (44) reported that degree of obesity per increase in unit distance walked declined to a greater degree for larger women than for leaner women. This suggestion does not challenge the widely held belief that running should elicit greater gains physiologically than walking, but suggests a scenario in which overweight or obese individuals who are attempting to alter their sedentary lifestyle can see improvements from an alternative exercise regimen that includes more manageable or tolerable moderate-intensity exercise (13). For walking and running, intensity and distance traveled per unit time is a direct product of pace. The greater the distance a person travels, the greater the energy expenditure (EE). There has been some suggestion that when EE is accounted for, knowledge of typical duration of exercise does not influence risk of CVD (22). Many exercise prescriptions are centered on time-based estimations of EE and some researchers have suggested that the generally accepted recommendation of 30 minutes per day of physical activity may not be enough to see attainable benefits (37). These same researchers stated that the minimal threshold is probably closer to 60 min/day and could be as high as 80 – 90 min/day of moderate intensity exercise (37).

If there is such potential variance in time-based exercise prescriptions and EE estimations, it is important to potentially consider other methods to evaluate or prescribe exercise. When considering walking or running as the exercise modality, distance-based estimations may provide an alternative means of prescribing exercise. Research has suggested that knowledge of distance walked or run had a relationship with improvements in body composition (44, 45). If this is the case, prescription of walking or running by distance rather than time may provide a better means for weight loss or weight maintenance (46). In fact, Williams (46, 47) reported in their cross-sectional data that the association observed in body mass index (BMI) and circumference measurements were much stronger when calculated from distance EE estimations compared to EE estimations based on time and intensity. Further, it was shown that estimated EE by distance walked rather than by time led to a significant reduction in the odds of a person reporting they were obese or possessed an unhealthy amount of excess abdominal weight (50). It was also suggested that time-based EE estimations may overestimate physical activity and EE by somewhere between 32 – 43% (46, 47). If so, then individuals could be potentially falling well short of meeting overall daily caloric expenditure requirements to

maintain or improve body weight status (46). Knowing the distance traveled provides a much closer estimate of EE than does time-based EE estimates that must consider not only the time but also the intensity. If intensity is not reported, then time estimations could be even further from the true EE.

If it is true that individuals substantially overestimate total exercise performed as a product of time or intensity as has been reported previously, a simple reworking of exercise guidelines to promote distance walking or running rather than time spent walking or running could provide a better estimate of total EE (24, 46, 47). The authors hypothesize that a distance-based exercise prescription will provide a better means for exercise adherence than a time-based exercise prescription and result in a larger improvement in body composition. Williams (46,47) contends that this change may potentially provide a better evaluator of EE for weight control programs. Williams (46) stated there is currently no research directly comparing walking distance and walking time and their effect on risk factors for cardiovascular disease. The purpose of this study was to compare a distance-based versus time-based walking prescription to evaluate whether either method encouraged a greater adherence to the exercise and if that adherence then leads to improvement in risk factors of CVD.

METHODS

Participants

The research was approved by the Institutional Review Board committee at the University of Mississippi for the use of human subjects. Informed consent was obtained from all participants in the study. The study included 15 participants from the Oxford, MS community. The desired participants were to be sedentary, overweight but otherwise healthy adults between the ages of 18 – 44 (males) and 18 – 54 (females). The Physical Activity Readiness Questionnaire (PAR-Q) was used to screen for any potential contraindications to exercise (41). Participants completed a 7-day physical activity questionnaire to determine physical activity status (35).

A participant was considered for the study if they were considered overweight but otherwise healthy as determined by answers to the PAR-Q. Each participant's body composition [total body fat mass (FM), abdominal body fat mass (AFM), fat-free mass (FFM)] was evaluated using dual energy x-ray absorptiometry (DXA) as measured by a Hologic Delphi, QDR series (Bedford, MA) apparatus and height and body mass were measured by standard scales upon arrival. Overall body fat percentage ranges for consideration in the study were determined using previously published recommendations based on gender and age (1). Overweight but otherwise healthy males were considered if their body fat percentage was greater than 22% and overweight but otherwise healthy females were considered if theirs was greater than 32% (1).

Protocol

Prior to any exercise intervention beginning, all participants underwent baseline testing. Once the pre-screening (Pre-intervention Visit 1) was completed and the participant met the inclusion standards, the participant was asked to return for resting baseline measurements at

least 24 hours later. The participants were required to be fasting from any food or alcohol for at least eight hours as well as abstaining from moderate-intensity exercise for at least two hours and vigorous-intensity exercise for at least 14 hours prior to any Pre-intervention Visit 2 data collection. The participants were required to also have abstained from caffeine for at least four hours and nicotine for two hours. Pre-intervention Visit 2 data collection involved resting blood levels of HDL cholesterol, LDL cholesterol, triglycerides (TG), total cholesterol (TC), and blood glucose (BG) using a Cholestech LDX system (Alere, Waltham, MA). Each participant had the ring finger on their non-dominant hand pricked to collect a capillary blood sample. Each blood sample amounted to 40 µL and was collected within 10 seconds. The use of this analyzer in measurement methodology has been previously validated (6). Following completion of this test each participant then had their resting metabolic rate (RMR) evaluated using indirect calorimetry. Each participant was asked to rest quietly while lying reclined at a 45° angle on a padded exercise bench with feet propped up for 20 minutes prior to any data collection beginning. The room in which measurements were made was kept in a comfortable temperature range of between 20 – 25°C. The measurement of RMR took approximately 30 – 40 minutes to complete (including the previously mentioned 20 minute rest period). All laboratory metabolic data (oxygen uptake, carbon dioxide production, pulmonary ventilation) related to RMR was measured using a ParvoMedics TrueOne 2400 (Sandy, Utah) measurement system and accompanying mouthpiece and nose-clamp. Once the mouthpiece and nose-clamp was in place and breath-by-breath analysis commenced, data collection continued for at least 10 minutes. The first five minutes of data collection was not considered for analysis and was discarded. The remaining five minutes of data was used for the RMR measurement as long as the coefficient of variation was no greater than 10%. RMR measurement was ended at this point if this criteria was met. If not, evaluation continued until the previously mentioned criteria were met. The described RMR protocol is based on previously published recommendations (8).

Pre-intervention Visit 3 involved the assessment of aerobic capacity. Indirect calorimetry was employed to measure oxygen consumption and related variables during treadmill walking or running using the ParvoMedics TrueOne 2400 measurement system. Each participant performed a submaximal treadmill test to predict VO_2 max using a modified Balke protocol (11). Exercise continued until heart rate (HR) reached 60% of predicted heart rate reserve (HRR). Independent regression equations were used to examine the VO_2 – HR association and VO_2 max was estimated at the extrapolated HR_{max}. Following completion of the submaximal VO_2 test, participants were permitted to leave, thus ending all pre-intervention measurements.

Prior to beginning the exercise intervention, the participants were assigned to the two treatment groups in a counter-balanced design in an attempt to limit differences in gender and aerobic capacity between the groups at baseline. One group was prescribed an aerobic exercise regimen based on an accumulated walking/running time per week (TIME) and the other group was prescribed an aerobic exercise regimen based on an accumulated walking/running distance (DIST) per week. Participants were informed about the difference between daily physical activity (such as walking from one class to another) and the planned exercise program to be followed and reported. All participants were instructed to report their exercise

completed per day and per week through use of a Qualtrics (Provo, UT) online survey to give a weekly self-report update on the exercise that had been performed that week. Participants were requested to refrain from other strenuous exercise and resistance training during the span of the intervention and were also asked to report weekly exercise as honestly and truthfully as possible and to not purposely over or underestimate time or distance. Participants in both groups were shown how to download and use the Nike Plus Running App (Beaverton, OR) which measures distance of each walk/run in addition to measuring time and pacing data. The DIST group participants were informed that they only needed to be concerned with their walk/run distances that were completed that week; the accumulation of the mileage was the main concern. They were informed that they could choose to walk or run the prescribed distance as they saw fit. The participants in the TIME group reported all of their completed walk/run exercise as time which was measured by the same Nike Plus Running App. The exercise prescription was encouraged to be completed at the participant's convenience and at their own pace.

The design of the exercise program aimed to keep total weekly caloric expenditure as close as possible between the two groups. This is exhibited in the outlines of the intervention styles are presented in Table 1 and were based on current recommendations based on a joint position statement from the American College of Sports Medicine (ACSM) and American Heart Association (1,14,30). Using the current recommendations for weekly EE, the separate prescriptions for the TIME and DIST groups were devised to prescribe the same caloric expenditure per week. The intervention lasted for 10 weeks which exceeded the minimum intervention length for a physical activity program employing self-report data as outlined in a review by Bravata et al. (5). Adherence statistics to each exercise regimen were compiled and contrasted following completion of the intervention. Adherence was calculated as amount of the prescribed exercise that was reported to the research team from the individual participant. If less than the prescribed weekly exercise was reported, a percentage < 100% would be calculated. If the actual amount of exercise reported that particular week was exactly the same as the amount that was prescribed, then a percentage of 100% would be calculated. If a greater amount of exercise was reported than was prescribed, a percentage of > 100% would be calculated. Only those participants that completed the intervention and were able to return for post-testing data collection were included in the analysis. Once the participants in the TIME group reached week 6 (as displayed in Table 1), they were encouraged to alternate 5-minute walk bouts with 5-minute run bouts in order to closely match weekly exercise prescription with the DIST group. This was done in order to keep exercise time prescription reasonable and achievable for a previously sedentary participant population.

Each participant was also given a 3-day food recall at baseline (Week 0), Week 5 (mid-point), and Week 10 (end-point). Each participant's dietary recall was evaluated using the Nutrient Data System (NDS; Minneapolis, MN, version 2011), a nutrient analysis software program designed for research. This software was provided by the NHM Nutrition Assessment Clinic at the University of Mississippi. Participants were requested to report intake for consumption on a typical three day period. Those participants who reported atypical consumption were asked to complete an additional 3-day record in order to allow assessment of a more "usual

consumption" pattern. If necessary, participants were asked to meet with one of the researchers for a verification interview. Specific nutrients of interests that were assessed included but were not limited to: energy (kcal), protein (g), carbohydrates (g), total fat (g), saturated fat (g), monounsaturated fat (g), polyunsaturated fat (g), iron (mg), calcium (mg), and vitamin D (IU). This data was collected in order to evaluate if there was a potential difference in blood lipids or BG for the groups, was there a difference in dietary intake which may have driven these differences.

Table 1. Program design and exercise prescription.

	TIME Group				DIST Group	
Week	**Days/Week**	**Time/Day (min)**	**Type**	**MIN kcal/week**	**Miles/Week**	**MIN kcal/week**
1	3 – 4	30	Walk	500	5	500
2	3 – 4	30	Walk	700	7	700
3	4 – 5	30	Walk	800	8	800
4	5	35	Walk	900	9	900
5	5	40	Walk	1000	10	1000
6	4 – 5	40	Walk/Run	1100	11	1100
7	4 – 5	45	Walk/Run	1200	12	1200
8	4 – 5	50	Walk/Run	1300	13	1300
9	4 – 5	55	Walk/Run	1500	15	1500
10	4 – 5	60	Walk/Run	1750	17.5	1750

Following completion of the 10-week intervention, participants returned individually to the lab to have post-testing completed. Post-test procedures mirrored pre-test procedures nearly exactly to evaluate effect of intervention. Exceptions included the following: Pre-intervention Visit 1 and 2 were combined for Post-intervention Visit 1 and all exercise procedures as before (Pre-intervention Visit 3) were performed at least 24 hours later. (Post-intervention Visit 2).

Statistical Analysis

A one-way ANOVA was used to compare baseline values (body mass, body composition, blood lipids, BG, RMR, VO_2 max). A one-way ANOVA was also used to compare dietary recall data (total caloric intake, protein, carbohydrate, total fat, saturated fat, monounsaturated fat, polyunsaturated fat, iron, calcium, and vitamin D). Additionally, a Brown-Forsythe test was used to evaluate homogeneity of variance for the two groups. An independent t-test was used to compare overall adherence to exercise rates between the two intervention styles. A mixed-factor repeated-measures ANOVA (RM-ANOVA) was used to compare all other dependent variables before and after intervention (body weight, body composition, blood lipids, BG, RMR, VO_2 max) for within-subjects and between-subjects. The independent variable is group assignment (either TIME or DIST). A mixed-factor RM-ANOVA was also used to compare weekly adherence rates to the exercise program. If interactions occurred, they were followed up with a Sidak adjustment for multiple pairwise comparisons. All analyses were conducted using SPSS software (Version 20, SPSS, Inc., Chicago, IL). Statistical significance was defined as a *p*-level less than 0.05 and eta squared was calculated to determine effect size.

RESULTS

The study was able to initially enroll 20 participants (10 in DIST group, 11 in TIME group) in the study. Of those 20, five participants did not complete the intervention and post-testing portions of the study and were thus not included in any analysis. Of those five drop-outs, one participant (from DIST group) dropped out due to sickness unrelated to the study, three participants dropped out due to previous commitments which prevented them from fully investing their time to the program (two from DIST group, one from TIME group), and another participant moved out-of-state prior to finishing the program and was unable to return for any post-testing (from DIST group). This left the total number of participants who completed the study at 15 (9 from TIME group, 6 from DIST group) and these were the participants that were eligible for data analysis. Of those nine participants in the TIME group, six were female and three were male. Of those six participants in the DIST group, three were female and three were male.

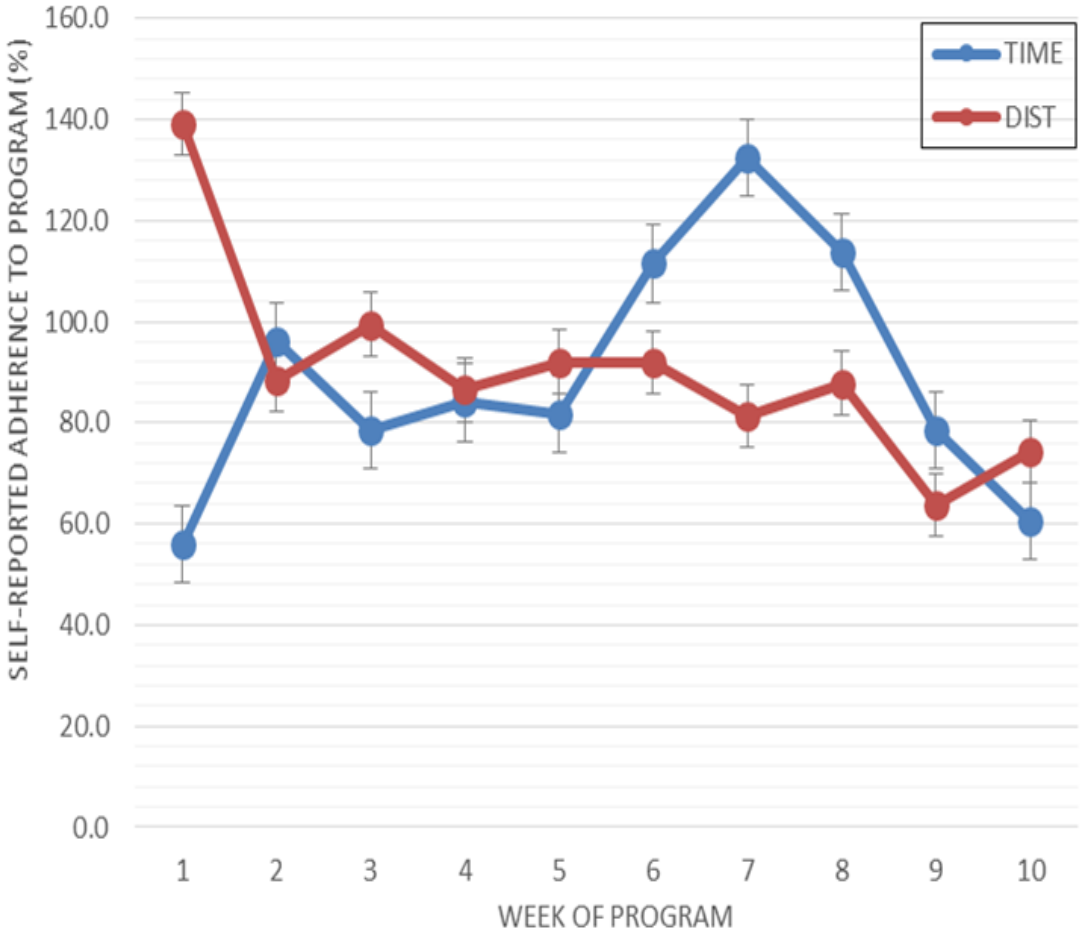

Figure 1. Self-reported adherence to exercise program rate per week.

Table 2 shows descriptive statistics pertaining to the overall adherence to the separate exercise programs. There was not a significant difference in adherence rates between groups (p =

0.949). The mean overall adherence rate was 89.8% (89.33% for TIME group, 90.5% for DIST group). Pertaining to the weekly adherence rate, RM-ANOVA showed that there was a significant difference in mean weekly adherence rate to the intervention at the following time points: Week 1 mean adherence for TIME group = 55.9%, DIST group = 139.07% ($F_{1,14}$ = 6.283, p = 0.026) and Week 7 mean adherence for TIME group = 132.5%, DIST group = 81.33% ($F_{1,14}$ = 8.706, p = 0.011). There was not shown to be a significant difference in weekly adherence rate between groups for all other weeks (Week 2: p = 0.766; Week 3: p = 0.476; Week 4: p = 0.916; Week 5: p = 0.663; Week 6: p = 0.766; Week 8: p = 0.252; Week 9: p = 0.575; Week 10: p = 0.593). Figure 1 displays this data with mean group adherence noted for each week of the program (separate lines for each group). Standard deviations for each weekly group mean are also displayed within Figure 1.

Table 2. Overall adherence rates to exercise program.

		TIME Group		DIST Group	
Variable	**Gender**	**Mean**	**SD**	**Mean**	**SD**
Overall	Combined	89.3	34.7	90.5	29.1
Adherence	M	77.7	32.0	75.0	36.0
Rate (%)	F	95.2	37.3	105.9	10.2

* p < 0.05 for within-groups comparison.

There was not a significant difference between groups for any of the reported dietary intake components: total caloric intake (p = 0.264), total fat (p = 0.225), saturated fat (p = 0.463), monounsaturated fat (p = 0.345), polyunsaturated fat (p = 0.282), carbohydrate (p = 0.665), protein (p = 0.641), calcium (p = 0.882), iron (p = 0.463), Vitamin D (p = 0.786).

Table 3. Physical characteristics of participants.

		TIME Group		DIST Group	
Variable		**Mean**	**SD**	**Mean**	**SD**
Age (years)	*Pre*	23.7	5.6	23.3	4.1
	Post	23.8	5.6	23.7	4.5
Height (m)	*Pre*	1.69	0.12	1.72	0.09
	Post	1.69	0.12	1.72	0.09
Body Mass	*Pre*	87.5[a]	19.2	103.9[a]	18.7
(kg)	*Post*	88.6[a]	22.2	99.9[b]	17.9
Body fat %	*Pre*	34.7	4.7	37.8	7.0
	Post	35.0	3.8	37.0	6.8
FM (kg)	*Pre*	30.4	6.9	38.5	10.2
	Post	30.9	7.7	37.0	10.4
FFM (kg)	*Pre*	56.3	13.4	64.6	12.6
	Post	57.7	16.0	62.8	12.0
AFM (kg)	*Pre*	9.8	3.3	15.1	5.8
	Post	10.2	3.5	13.6	4.5
BMD	*Pre*	1.30	0.13	1.30	1.00
(g/cm^3)	*Post*	1.30	0.14	1.28	0.09

* p < 0.05 for within-groups comparison. Different letters indicate significant interaction present (p < 0.05) for between-groups comparison. FM = fat mass, FFM = fat-free mass, AFM = abdominal fat mass, BMD = bone mineral density.

Table 3 shows physical characteristics of the study sample prior to and following completion of the exercise intervention. There were no significant differences ($p > 0.05$) in physical characteristics between the two groups at baseline (age, height, body mass, body fat percentage, FM, FFM, AFM, BMD). RM-ANOVA did not show evidence of a significantly different value from pre-to-post or between groups for the following dependent variables: body fat percentage ($p = 0.605$), FFM ($p = 0.914$), FM ($p = 0.410$), or BMD ($p = 0.284$). RM-ANOVA also showed that there was not a significant difference for the main effect pre-to-post in mean body mass following the intervention ($p = 0.187$), however there was a significant interaction between pre-to-post between groups $F_{1,13} = 6.337$ ($p = 0.026$, $\eta^2 = 0.328$). Pairwise multiple comparison procedures were conducted to identify significant differences in simple effects due to the existence of a significant interaction; $F_{1,13} = 6.375$ ($p = 0.025$, $\eta^2 = 0.329$). This significant interaction is demonstrated as the DIST group declined in mean body mass by -4.0 kg while the TIME group increased their mean body mass by 1.1 kg. RM-ANOVA additionally showed that there was not a significant difference for the main effect pre-to-post in mean AFM following the intervention ($p = 0.258$), nor was there a significant interaction between pre-to-post between groups ($p = 0.072$). Despite the lack of a significant relationship in AFM either between groups or following intervention, a possible link is demonstrated as the DIST group declined in mean AFM by -1.5 kg while the TIME group increased their mean AFM by 0.4 kg.

Table 4. Fasting blood lipid panel and blood glucose level of participants.

		TIME Group		DIST Group	
Variable		**Mean**	**SD**	**Mean**	**SD**
TC	*Pre*	171.9	29.5	165.3	37.2
(mg/dL)	*Post*	163.3	24.1	167.2	42.4
LDL	*Pre*	95.3	22.3	96.4	36.5
(mg/dL)	*Post*	92.1	25.2	95.5	27.2
HDL	*Pre*	50.4	21.2	50.3	17.9
(mg/dL)	*Post*	45.3	17.3	53.0	24.7
TG	*Pre*	127.9	58.6	92.8	41.6
(mg/dL)	*Post*	124.8	63.2	82.8	50.6
BG	*Pre*	84.6 [a]	8.8	92.8 [a]	7.1
(mg/dL)	*Post*	89.2 [a]	10.5	82.3 [b]	4.0

* $p < 0.05$ for within-groups comparison. Different letters indicate significant interaction present ($p < 0.05$) for between-groups comparison. TC = total cholesterol, LDL = low-density lipoproteins, HDL = high-density lipoproteins, TG = trigylcerides, BG = blood glucose.

Table 4 shows fasting blood lipid panel and BG levels of the study sample prior to and following completion of the exercise intervention. There were no significant differences ($p > 0.05$) in blood lipids (TC, LDL, HDL, TG) or BG between the two groups at baseline. RM-ANOVA showed that the following dependent variables did not show evidence of a significant differently value from pre-to-post or between groups: TC ($p = 0.536$), LDL ($p = 0.771$), HDL ($p = 0.597$), or TG ($p = 0.666$). RM-ANOVA also showed that there was not a significant difference for the main effect pre-to-post in mean BG following the intervention ($p = 0.306$), however there was a significant interaction between pre-to-post between groups $F_{1,13} = 7.681$ ($p = 0.016$, $\eta^2 = 0.371$). Pairwise multiple comparison procedures were conducted to identify significant differences in simple effects due to the existence of a significant interaction; $F_{1,13} = 6.136$ ($p = 0.028$, $\eta^2 = 0.321$). This significant interaction is demonstrated as the DIST

group declined in mean BG by -10.5 mg/dL while the TIME group showed an increase in their mean BG by 4.7 mg/dL.

Table 5 shows RMR and VO_2 max data of the study sample prior to and following completion of the exercise intervention. There were no significant differences ($p > 0.05$) between the two groups at baseline for either RMR or VO_2 max. The mean baseline RMR was 1692.2 kcal/day for TIME group, 1858.8 kcal/day for DIST group. The mean baseline VO_2 max of the participants was 34.5 mL/kg/min for TIME group and 34.7 mL/kg/min for DIST group. RM-ANOVA showed that neither of these dependent variables showed evidence of a significantly different value from pre-to-post or between groups; RMR ($p = 0.710$), VO_2 max ($p = 0.127$). The mean post-intervention RMR was 1828.6 kcal/day for TIME group and 1765.7 kcal/day for DIST group. The mean post-intervention VO_2 max of the participants was 35.2 mL/kg/min for TIME group, 40.4 mL/kg/min for DIST group.

Table 5. Estimated metabolic data of participants.

		TIME Group		DIST Group	
Variable		**Mean**	**SD**	**Mean**	**SD**
RMR	*Pre*	1692.2	415.0	1858.8	203.2
(kcal/day)	*Post*	1828.6	345.2	1765.7	220.7
VO_2 max	*Pre*	34.5	6.0	34.7	6.1
(mL/kg/min)	*Post*	35.2	3.9	40.4	10.8

* $p < 0.05$ for within-groups comparison. Different letters indicate significant interaction present ($p < 0.05$) for between-groups comparison. RMR = resting metabolic rate

DISCUSSION

The current study was an exploratory study aimed at investigating whether a distance-based exercise prescription of walking and running may improve risk factors for CVD to a greater degree than a more traditional method of prescribing walking or running exercise by time. The DIST group saw an improvement in their body mass with an average weight loss of 4.0 kg while the TIME group showed an increase in their body mass up 1.1 kg. The difference between the baseline body (and abdominal) masses of the groups, though not significant, could have possibly masked any significant improvements experienced by the DIST group as is suggested by the significant interaction that was observed. A very similar link was shown for AFM with an average loss of 1.5 kg for the DIST group while the TIME group increased by an average of 0.4 kg. Upon evaluation of overall body composition measures, a fairly consistent link emerged with the DIST group exhibiting a small decline in body fat percentage which led to decreases in both FFM and FM. The opposite was true of the TIME group showing small increases in overall body fat percentage, FFM, and FM. Being that this was a 10-week intervention employing predominantly moderate-intensity exercise (with some small amounts of vigorous-intensity) alone rather than exercise plus diet suggests that any improvements experienced within this relatively short amount of time would be minimal. More extreme weight losses often receive the greater bulk of the attention and acclaim, but even a modest weight loss as little as 5% of previous body weight can lead to positive health benefits (3, 12). The DIST group showed a weight loss of about 3.8% during this 10-week period, while not reaching the previously mentioned 5% threshold, it can certainly be

suggested that the members of this group should be on-track to seeing the improvements in body weight that would be considered successful as suggested by previous research (3, 13).

The overall adherence rates were not significantly different between the two groups with the DIST group reporting an average of 90.5% while the TIME group reported an average of 89.3%. There were instances where participants reported accumulating a greater number of miles or length of time than prescribed. This is the reason for there being cases where adherence was reported as greater than 100%. Despite only seeing a significant improvement in two variables for the DIST group (body mass and BG), this 90.5% adherence rate seems to support the notion that significantly improving those two variables requires a strong adherence rate such as this in a short-term 10-week period. However, it is somewhat surprising for the TIME group in particular that such a high level of adherence to the program was reported while actually seeing the overall body mass and BG increase. The reason may partially be found in previous work by Williams and others (33, 46, 47). Williams reported that estimated EE was between 32 – 43% greater when calculated from time compared to distance, suggesting that EE estimations based on time are much more likely to overestimate EE than EE based on distance (46, 47). If the self-reported exercise for the TIME group in this study is closer to around 47 – 57% as the research by Williams (46, 47) suggests, this may partially explain why the TIME group saw minimal, if any, improvements in overall risk factor reduction and actually gained weight as a result of the intervention. If the TIME group participants participated in closer to half of the program as Williams' (46, 47) research suggests, these participants may not have performed enough exercise to lead to any substantial changes in their body composition or other related CVD risk factors.

Blood cholesterol and glucose levels are certainly dependent on day-to-day dietary habits, but possible small improvements experienced by the participants in the study can potentially be suggestive of success of the exercise program as well. Main effect changes in BG levels were also masked in the same manner as body mass changes as described earlier. The DIST group improved their BG by an average decline of 10.5 mg/dL while the TIME group saw an increase in their BG by an average of 4.7 mg/dL. This improvement in BG occurring alongside a loss in body mass would seem to support previous research which suggests these two factors tend to coincide with weight loss programs and overall improvement of risk factors for CVD (23, 38, 43). This suggests that not only was the distance-based program more successful than the time-based program at leading to a loss in body mass, but also lead to an improvement in BG levels which are essential for overall risk for CVD as well as prevention of Type II Diabetes Mellitus (38).

When making an evaluation of the lack of a significant difference seen in the dietary recall data, it doesn't appear that dietary habits contributed to any of the potential differences seen for blood lipid or glucose data. The results of this study for measurements of TC and LDL supports what has been reported previously showing minimal, if any, improvements in TC and LDL following a short-term exercise program centered on predominantly moderate-intensity exercise, regardless of body weight changes (3, 9, 12, 18, 19, 26, 34, 40, 48, 49). However, both groups showed small (though insignificant) improvements in TG levels,

suggesting that the exercise program (even without the mass loss in the case of the TIME group) led to small improvements in blood lipid results. Previous literature has suggested a minimal threshold EE of at least 1000 – 1200 kcal/week to see any improvements in TG levels (9, 16, 17, 21, 34, 49, 51). It's plausible that the exercise completed was not sufficient to observe substantial changes (due to overweight status and low levels of prescribed exercise) due to the low levels of exercise training that was initially prescribed. Examination of HDL levels revealed that the TIME group actually declined by 5.11 mg/dL and increased for the DIST group by 2.67 mg/dL. Previous literature suggests that a minimal threshold of 1200 – 2200 kcal/week must be reached in order to experience substantial improvements in HDL levels (4, 9, 10, 11, 14, 16, 17, 20, 25, 30, 36, 39, 42). HDL levels can vary by approximately 1.5 mg/dL day-to-day so this suggests these changes are accurate measurements of change rather than simply from day-to-day variability (32). While this difference was not considered significant, taking the limitations from sample size and lower levels of exercise into account, it's possible that the DIST group showed an improvement over the TIME group in this risk factor for CVD.

The difference in pre-to-post VO_2 max for DIST group was an increase of 5.8 mL/kg/min and 0.7 mL/kg/min for the TIME group. This difference in levels of improvement between the groups, while not significant, could also be partially explained by the expression of VO_2 max to body mass. If a loss in body mass is experienced even without an improvement in absolute aerobic capacity, relative aerobic capacity would increase purely as a result in the change in body mass. Additionally, VO_2 max was estimated from measurement from a submaximal test rather than being quantified from a maximal test.

The RMR for the DIST group decreased by approximately 93.1 kcal/day on average and the RMR for the TIME group increased on average by about 136.4 kcal/day. While this was not a significant or difference, it is perhaps of interest that the RMR of one group appeared to increase while the other decreased slightly. It is possible that this could be related to the gain in body mass by the TIME group (1.1 kg) and the loss in body mass by the DIST group (4.0 kg). While the differences therein do not create a perfect relationship, it is plausible that due to the gain in body mass (including a slight gain in FFM, though insignificant) that was experienced by the TIME group that their RMR increased as well. It's additionally possible that due to the DIST group losing body mass (including a slight, but insignificant loss in FFM) the RMR of those participants could have declined.

An attempt was made to meet the median and mode group sizes employed in previous weight loss interventions outlined by Miller, Koceja, and Hamilton (27). Of the initial 20 volunteers, five participants were not able to complete 10-week intervention program. This represents a 25% dropout rate which is fairly comparable to drop-out rates reported by other researchers in similar short-term exercise programs which have employed self-reports of brisk walking for previously sedentary adults. In an 18-week study, Woolf-May et al. (50) had a drop-out rate of 29.1%. In their 16-week study, Coleman et al. (7) experienced a drop-out rate of 11%. A 12-week study by Murphy, Nevill, Neville, Biddle, and Hardman (28) reported a drop-out rate of 42.9%. Another 12-week study reported a drop-out rate of 29% (29). The observed power was 0.646 for the significant change in body weight experienced by the DIST group. While some

implications can certainly be made from this data set, based on the sample size issues it may be difficult to draw definitive conclusions. However, taking the sample size issues into account, it does appear that the distance-based program led to some important improvements in a few of the risk factors for CVD.

A limitation of this study is that data on EE performed by each participant was not collected. Exercise was prescribed to participants either by distance or by time. As previously mentioned, the amount of exercise that was prescribed for the DIST group was determined based on the estimated EE that the completion of that particular mileage would equate to. The researchers started with the standard ACSM guidelines for aerobic exercise prescription when formulating the exercise prescription for the TIME group and formulated the prescription for the DIST group based on the estimated EE that the members of the TIME group would complete. Future studies should more closely monitor overall EE to assess if the actual EE performed by participants closely mirrors what was prescribed.

To the best of the authors' knowledge, the present study is the first to directly compare a distance-based vs. a time-based exercise program for walking and running for improvement of risk factors of CVD. The results of this study suggest that a distance-based exercise prescription of walking or running should provide a clinician or researcher with a closer estimation of overall EE and resultant weight loss and reduction of particular risk factors for CVD. The sample sizes achieved with this particular study are lower than what was intended but being that this study is a novel design an exploratory in nature, future research should attempt to recruit a larger sample size carried out to a longer duration, allowing the weekly prescribed EE to be increased to see if the same relationships hold true that have been suggested in this study. Also, inclusion of time exercised by the DIST group to compare against a TIME group as well as measures to evaluate the influence that perception of how pacing of the exercise may influence the likelihood to maintain or improve the exercise behavior would be key points of interest.

REFERENCES

1. American College of Sports Medicine. ACSM's Guidelines for Exercise Testing and Prescription. 9th Edition. Philadelphia, PA: Wolters Kluwer/Lippincott Williams & Wilkins; 2014.

2. American Heart Association. Heart disease and stroke statistics – 2017 update: A report from the American Heart Association. Circulation 135: 00-00, 2017.

3. Blackburn G. Effect of degree of weight loss on health benefits. Obes Res 3(S2): 211s-216s, 1995.

4. Blumenthal JA, Matthews K, Fredrikson M, Rifai N, Schniebolk S, German D, Steege J, Rodin J. Effects of exercise training on cardiovascular function and plasma lipid, lipoprotein, and apolipoprotein concentrations in premenopausal and postmenopausal women. Arterioscler Thromb Vasc Biol 11: 912-917, 1991.

5. Bravata DM, Smith-Spangler C, Sundaram V, Gienger AL, Lin N, Lewis R, Stave CD, Olkin I, Sirard JR. Using pedometers to increase physical activity and improve health: A systematic review. J Amer Med Assoc 298(19): 2296-2304, 2007.

6. Carey M, Markham C, Gaffney P, Boran C, Maher V. Validation of a point of care lipid analyzer using a hospital based reference laboratory. Irish J Med Sci 175(4): 30-35. 2006.

7. Coleman KJ, Raynor HR, Mueller DM, Cerny FJ, Dorn JM, Epstein LH. Providing sedentary adults with choices for meeting their walking goals. Prev Med 28: 510-519, 1999.

8. Compher C, Frankenfield D, Keim N, Roth-Yousey L. Best practice methods to apply to measurement of resting metabolic rate in adults: A systematic review. J Am Diet Assoc 106: 881-903, 2006.

9. Durstine JL, Grandjean PW, Davis PG, Ferguson MA, Alderson NL, DuBose KD. Blood lipid and lipoprotein adaptations to exercise: A quantitative analysis. Sports Med 31(15): 1033-1062, 2001.

10. Farrell PA, Barboriak J. The time course of alterations in plasma lipid and lipoprotein concentrations during eight weeks of endurance training. Atherosclerosis 37(2): 231-238, 1980.

11. Froelicher VF, Brammell H, Davis G, Noguera I, Stewart A, Lancaster MC. A comparison of the reproducibility and physiologic response to three maximal treadmill exercise protocols. Chest 65: 512-517, 1974.

12. Goldstein DJ. Beneficial health effects of modest weight loss. Int J Obes Relat Metab Disord 16(6): 397-415, 1992.

13. Gordon-Larsen P, Hou N, Sidney S, Sternfield B, Lewis CE, Jacobs DR, Popkin BM. Fifteen-year longitudinal trends in walking patterns and their impact on weight change. Amer J Clin Nutr 89: 19-26, 2009.

14. Grandjean PW, Crouse SF, O'Brien BC, Rohack JJ, Brown JA. The effects of menopausal status and exercise training on serum lipids and the activities of intravascular enzymes related to lipid transport. Metab 47(4): 377-383, 1998.

15. Haskell WL, Lee IM, Pate RR, Powell KE, Blair SN, Franklin B, Macera CA, Heath GW, Thompson PD, Bauman A. Physical activity and public health: Updated recommendation for adults from the American college of sports medicine and the American heart association. Med Sci Sport Exerc 39(8): 1423-1434, 2007.

16. Hinkleman LL, Nieman DC. The effects of a walking program on body composition and serum lipids and lipoproteins in overweight women. J Sport Med Phys Fit 33(1): 49-58, 1993.

17. Huttunen JK, Länsimies E, Voutilainen E, Ehnholm C, Hietanen E, Penttilä I, Siitonen O, Rauramaa R. Effect of moderate physical exercise on serum lipoproteins: a controlled clinical trial with special reference to serum high-density lipoproteins. Circulation 60(6): 1220-1229, 1979.

18. Kiens B, Jorgenson I, Lewis S, Jensen G, Lithell H, Vessby B, Hoe S, Schnohr P. Increased plasma hdl cholesterol and apo a-i in sedentary middle-aged men after physical conditioning. J Clin Invest 10(3): 203-209, 1980.

19. Kokkinos PF, Holland JC, Narayan P, Colleran JA, Dotson CO, Papademetriou V. Miles run per week and high-density lipoprotein cholesterol levels in healthy middleaged men: A dose-response relationship. Arch Intern Med 155(4): 415-420, 1995.

20. Lamarche B, Després JP, Pouliot MC, Moorjani S, Lupien PJ, Thériault G, Tremblay A, Nadeau A, Bouchard C. Is body fat loss a determinant factor in the improvement of carbohydrate and lipid metabolism following aerobic exercise training in obese women? Metab 41(11): 1249-1256, 1992.

21. Lampman RM, Santinga JT, Savage PJ, Bassett DR, Hydrick CR, Flora JD, Block WD. Effects of exercise training in glucose tolerance, in vivo insulin sensitivity, lipid and lipoprotein concentrations in middle-aged men with mild hypertriglyceridemia. Metab 34(3): 205-211, 1985.

22. Lee IM, Sesso HD, Paffenbarger S. Physical activity and coronary heart disease risk in men: Does the duration of exercise episodes predict risk? Circulation 102: 981-986, 2000.

23. Lindström J, Louheranta A, Mannelin M, Rastas M, Salminen V, Eriksson J, Uusitupa M, Tuomilehto J. The Finnish Diabetes Prevention Study (DPS): Lifestyle intervention and 3-year results on diet and physical activity. Diabetes Care 26(12): 3230-3236, 2003.

24. Luke A, Dugas LR, Durazo-Arvizu RA, Cao G, Cooper RS. Assessing physical activity and its relationship to cardiovascular risk factors: NHANES 2003-2006. BMC Public Health 11: 387, 2011.

25. Marti B, Suter E, Riesen WF, Tschopp A, Wanner HU, Gutzwiller F. Effects of long-term, self-monitored exercise on the serum lipoprotein and apolipoprotein profile in middle-aged men. Atherosclerosis 81(1): 19-31, 1990.

26. Martin RP, Haskell WL, Wood,PD. Blood chemistry and lipid profiles of elite distance runners. Ann NY Acad Sci 301: 346-360, 1977.

27. Miller WC, Koceja DM, Hamilton EJ. A meta-analysis of the past 25 years of weight loss research using diet, exercise or diet plus exercise intervention. Int J Obes 21: 941-947, 1997.

28. Murphy M, Nevill A, Neville C, Biddle S, Hardman A. Accumulating brisk walking for fitness, cardiovascular risk, and psychological health. Med Sci Sport Exerc 34(9): 1468-1474, 2002.

29. Murtagh EM, Boreham CAG, Nevill A, Hare LG, Murphy MH. The effects of 60 minutes of brisk walking per week, accumulated in two different patterns, on cardiovascular risk. Prev Med 41: 92-97, 2005.

30. Nieman DC, Warren BJ, O'Donnell KA, Dotson RG, Butterworth DE, Henson DA. Physical activity and serum lipids and lipoproteins in elderly women. J Am Geriatr Soc 41(12): 1339-1344, 1993.

31. Pate RR, Pratt M, Blair SN, Haskell WL, Macera CA, Bouchard C, Buchner D, Ettinger W, Heath GW, King AC, Kriska A, Leon AS, Marcus BH, Morris J, Paffenbarger RS, Patrick K, Pollock ML, Rippe JM, Sallis J, Willmore JH. Physical activity and public health: A recommendation from the centers for disease control and prevention from the American college of sports medicine. J Am Med Assoc 273(5): 402-407, 1995.

32. Pereira MA, Weggemans RM, Jacobs DR, Hannan PJ, Zock PL, Ordovas JM, Katan MB. Within-person variation in serum lipids: Implications for clinical trials. Int J Epidemiol 33: 534-541, 2004.

33. Prince SA, Adamo KB, Hamel ME, Hardt J, Gorber SC, Tremblay M. A comparison of direct versus self-report measures for assessing physical activity in adults: A systematic review. Int J Behav Nutr Phys 5(56): 1-24, 2008.

34. Raz I, Rosenblit H, Kark JD. Effect of moderate exercise on serum lipids in young men with low high density lipoprotein cholesterol. Arterioscl Throm Vas 8: 245-251, 1988.

35. Sallis JF, Haskell WL, Wood PD. Physical activity assessment methodology in the five-city project. Am J Epidemiol 121: 91-106, 1985.

36. Santiago MC, Leon AS, Serfass RC. Failure of 40 weeks of brisk walking to alter blood lipids in normolipemic women. Can J Appl Physiol 20(4): 417-428, 1995.

37. Saris WHM, Blair SN, van Baak MA, Eaton SB, Davies PSW, Di Pietro L, Fogelholm M., Rissanen A, Schoeller D, Swinburn B, Tremblay A, Westerterp KR, Wyatt H. How much physical activity is enough to prevent unhealthy weight gain? Outcome of the IASO 1st stock conference and consensus statement. Obes Rev 4: 101-114, 2003.

38. Sigal RJ, Kenny GP, Wasserman DH, Castaneda-Sceppa C, White RD. Physical activity/exercise and type 2 diabetes: A consensus statement from the American Diabetes Association. Diabetes Care 29(6): 1433-1438, 2006.

39. Stein RA, Michielli DW, Glantz MD, Sardy H, Cohen A, Goldberg N, Brown CD. Effects of different exercise training intensities on lipoprotein cholesterol fractions in healthy middle-aged men. Am Heart J 119(2.1): 277-283, 1990.

40. Superko HR. Exercise training, serum lipids and lipoprotein particles: Is there a change threshold? Med Sci Sport Exerc 23(6): 677-685, 1991.

41. Thomas S, Reading J, Shephard RJ. Revision of the physical activity readiness questionnaire (par-q). Can J Sport Sci 17(4): 338-345, 1992.

42. Thomas TR, Adeniran SB, Etheridge GL. Effects of different running programs on VO2 max, percent fat and plasma lipids. Can J Appl Sport Sci 9(2): 55-62, 1984.

43. Tuomilehto J, Lindström J, Eriksson JG, Valle TT, Hämäläinen H, Ilanne-Parikka P, Keinänen-Kiukaanniemi S, Laakso M, Louheranta A, Rastas M, Salminen V, Uusitupa M. Prevention of type 2 diabetes mellitus by changes in lifestyle among subjects with impaired glucose tolerance. New Engl J Med 344(18): 1343-1350, 2001.

44. Williams PT. Nonlinear relationships between weekly walking distance and adiposity in 27,596 women. Med Sci Sport Exerc 37(11): 1-20, 2005.

45. Williams PT. Association between walking distance and percentiles of body mass index in older and younger men. Br J Sport Med 42: 352-356, 2008.

46. Williams PT. Advantage of distance- versus time-based estimated of walking in predicting adiposity. Med Sci Sport Exerc 44(9): 1728-1737, 2012a.

47. Williams PT. Non-exchangeability of running vs. other exercise in their association with adiposity, and its implications for public health recommendations. PLoS ONE 7(7): e36360, 2012b.

48. Wood PD, Haskell WL, Stern MP, Perry C. Plasma lipoprotein distributions in male and female runners. Ann NY Acad Sci 301, 748-763, 1977.

49. Wood PD, Stefanick ML, Dreon DM, Frey-Hewitt B, Garay SC, Williams PT, Superko R, Fortmann SP, Albers JJ, Vranizan KM, Ellsworth NM, Terry RB, Haskell WL. Changes in plasma lipids and lipoproteins in overweight men during weight loss through dieting as compared with exercise. New Engl J Med 319(18): 1173-1179, 1988.

50. Woolf-May K, Kearney EM, Owen A, Jones DW, Davison RCR, Bird SR. The efficacy of accumulated short bouts versus single daily bouts of brisk walking in improving aerobic fitness and blood lipid profiles. Health Educ Res 14(6): 803-815, 1999.

51. Wynne TP, Frey MA, Laubach LL, Glueck CJ. Effect of a controlled exercise program on serum lipoprotein levels in women on oral contraceptives. Metab 29(12): 1267-1271, 1980.