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Demographic, Clinical, and Psychosocial Predictors of Exercise Adherence: The STRRIDE Trials

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ABSTRACT

Purpose: This study aimed to identify baseline demographic, clinical, and psychosocial predictors of exercise intervention adherence in the Studies of Targeted Risk Reduction Intervention through Defined Exercise (STRRIDE) trials. **Methods:** A total of 947 adults with dyslipidemia or prediabetes were enrolled into an inactive control group or 1 of 10 exercise interventions with doses of 10–23 kcal·kg^{-1}·wk^{-1}, intensities of 40%–80% of peak oxygen consumption, and training for 6–8 months. Two groups included resistance training. Mean percent aerobic and resistance adherence were calculated as the amount completed divided by the prescribed weekly minutes or total sets of exercise times 100, respectively. Thirty-eight clinical, demographic, and psychosocial measures were considered for three separate models: 1) clinical + demographic factors, 2) psychosocial factors, and 3) all measures. A backward bootstrapped variable selection algorithm and multiple regressions were performed for each model. **Results:** In the clinical and demographic measures model (n = 947), variables explained 16.7% of the variance in adherence ($P < 0.001$); lesser fasting glucose explained the greatest amount of variance (partial R^2 = 3.2%). In the psychosocial factors model (n = 561), variables explained 19.3% of the variance in adherence ($P < 0.001$); greater 36-Item Short Form Health Survey (SF-36) physical component score explained the greatest amount of variance (partial R^2 = 8.7%). In the model with all clinical, demographic, and psychosocial measures (n = 561), variables explained 22.1% of the variance ($P < 0.001$); greater SF-36 physical component score explained the greatest amount of variance (partial R^2 = 8.9%). SF-36 physical component score was the only variable to account for >5% of the variance in adherence in any of the models. **Conclusions:** Baseline demographic, clinical, and psychosocial variables explain approximately 22% of the variance in exercise adherence. The limited variance explained suggests that future research should investigate additional measures to better identify participants who are at risk for poor exercise intervention adherence.

INTRODUCTION

There are numerous health benefits of regular participation in exercise and physical activity, yet approximately 117 million American adults have one or more preventable chronic diseases (1–3). Seven of the 10 most common chronic diseases could be positively affected by exercise and physical activity participation (4–6). Although most individuals recognize the importance of exercise and physical activity, according to the 2018 Physical Activity Guidelines for Americans, only 26% of men and 19% of women achieve the weekly recommended amount of aerobic and resistance exercise (1). Even among individuals motivated to join exercise interventions, approximately 20%–30% either drop out or have poor adherence to the intervention (7–11).

Countless self-recognized factors impede an individual's ability to successfully adopt and adhere to lifestyle interventions such as exercise (11–14). In the Studies of Targeted Risk Reduction Intervention through Defined Exercise (STRRIDE) trials, participants who dropped out (i.e., 0% adherence) reported lack of time, lack

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of motivation, health issues, changing their mind, transportation issues, family issues, and work responsibilities as barriers to participation (10). Although understanding these self-reported factors of intervention dropout and adherence is important, the retrospective nature of this information has inherent limitations. Therefore, identifying individuals at risk for poor adherence before initiating an intervention may be an important step for optimizing exercise adoption and adherence behavior.

Few studies have investigated exercise intervention adherence behavior predictors, leaving a significant knowledge gap. The three STRRIDE trials examined the differential effects of exercise amount, mode, and intensity on cardiometabolic health among previously sedentary adults with overweight or obesity and either dyslipidemia or prediabetes (15–17). The STRRIDE trials collected extensive demographic, clinical, and psychosocial data from participants before exercise intervention initiation, and objectively determined intervention adherence. Thus, these studies offer an opportunity to conduct secondary analyses determining whether a combination of readily available baseline demographic, clinical, and psychosocial factors comprises a model predicting exercise intervention adherence behavior.

METHODS

Study Participants

Predictors of exercise intervention adherence were assessed in participants from STRRIDE I (15), STRRIDE Aerobic Training and/or Resistance Training (AT/RT) (16), and STRRIDE-Prediabetes (PD) (17). STRRIDE I (1999–2003) and STRRIDE AT/RT (2004–2008) enrolled previously sedentary men and women with overweight or obesity (25–35 $kg \cdot m^{-2}$) and mild to moderate dyslipidemia (classified by low-density lipoprotein (LDL) cholesterol 130–190 $mg \cdot dL^{-1}$ or high-density lipoprotein (HDL) cholesterol ≤40 $mg \cdot dL^{-1}$ for men and <45 $mg \cdot dL^{-1}$ for women) (15,16). Participants were enrolled at either Duke University or East Carolina University (ECU). STRRIDE-PD (2009–2012) enrolled previously sedentary men and women with overweight or obesity and prediabetes (defined as two consecutive fasting glucose concentrations ≥95 to <126 $mg \cdot dL^{-1}$ taken 1 wk apart) (17). Participants were enrolled only at Duke University.

Table 1 describes the randomized exercise intervention groups across each STRRIDE trial (15–17). Both STRRIDE I (NCT00200993) and STRRIDE AT/RT (NCT00275145) study protocols were approved by the institutional review boards at Duke University and ECU. The STRRIDE-PD (NCT00962962) study protocol was approved by the institutional review board at Duke University. Participants provided both verbal and written informed consent. Baseline demographic characteristics were collected upon enrollment into one of the STRRIDE trials.

Intervention Details

There were study design differences across the three STRRIDE trials. In STRRIDE I, to allow gradual adaptation to their exercise prescription, participants underwent an initial ramp period of 2–3 months to exercise at their prescribed level. The ramp period was followed by an additional 6 months of

TABLE 1.
STRRIDE Randomized Exercise Intervention Groups.

Intervention Group	Exercise Prescription	
STRRIDE I		
Inactive control	—	—
High amount/vigorous intensity	23 KKW or 20 miles·wk^{-1}	65%–80% $\dot{V}O_{2peak}$
Low amount/vigorous intensity	14 KKW or 12 miles·wk^{-1}	65%–80% $\dot{V}O_{2peak}$
Low amount/moderate intensity	14 KKW or 12 miles·wk^{-1}	40%–55% $\dot{V}O_{2peak}$
STRRIDE AT/RT		
Aerobic training (low amount/vigorous intensity)	14 KKW or 12 miles·wk^{-1}	65%–80% $\dot{V}O_{2peak}$
Resistance training	3 d·wk^{-1}, 3 sets per day, 8–12 reps of 8 exercises	
Aerobic + resistance training	14 KKW or 12 miles·wk^{-1} at 65%–80% $\dot{V}O_{2peak}$ + 3 d·wk^{-1}, 3 sets per day, 8–12 reps of 8 exercises	
STRRIDE-PD		
High amount/vigorous intensity	16 KKW or 13.8 miles·wk^{-1}	65%–80% $\dot{V}O_{2peak}$
High amount/moderate intensity	16 KKW or 13.8 miles·wk^{-1}	40%–55% $\dot{V}O_{2peak}$
Low amount/moderate intensity	10 KKW or 8.6 miles·wk^{-1}	40%–55% $\dot{V}O_{2peak}$
Combined lifestyle intervention	10 KKW or 8.6 miles·wk^{-1} at 40%–55% $\dot{V}O_{2peak}$ + diet to reduce 7% body weight	

KKW, kcal/kilogram of body weight/week.

training at the appropriate exercise prescription. Prescribed exercise intensity was based on each participant's baseline cardiopulmonary exercise test results. Aerobic exercise modes included treadmills, elliptical trainers, cycle ergometers, or any combination of these.

In STRRIDE AT/RT, participants completed a 4-month inactive control period (run-in) before exercise intervention randomization. After randomization, participants underwent an 8- to 10-wk ramp period to allow for gradual adaptation to their exercise prescription. The ramp period was followed by an additional 5–6 months of training at the appropriate exercise prescription. For the aerobic training groups, prescribed exercise intensity was based on each participant's baseline cardiopulmonary exercise test results. Aerobic exercise modes included treadmills, elliptical trainers, cycle ergometers, or any combination of these. For the resistance training groups, participants started with one set during weeks 1–2, increased to two sets during weeks 3–4, and built up to the three-set prescription in week 5. A trained exercise physiologist used trial and error methods to determine a participant's optimal weight that could be lifted for 8–12 repetitions. Resistance exercises included the upper body (bench press, military (or overhead) press, lat pull, seated row, back extension (or bicep flexion and triceps extension)) and lower body (leg extension, leg flexion, and leg press).

In STRRIDE-PD, participants completed a 3-month inactive control period (run-in) before exercise intervention randomization. After randomization, participants underwent an approximately 10-wk ramp period to allow gradual adaptation to their exercise prescription; however, the total length of the exercise intervention was 6 months, regardless of the length of the ramp period. Prescribed exercise intensity was based on each participant's baseline cardiopulmonary exercise test results. Aerobic exercise modes included treadmills, elliptical trainers, cycle ergometers, or any combination of these. The combined lifestyle group in STRRIDE-PD received an intervention modeled after the Diabetes Prevention Program (18). This group was designed to achieve 7% weight loss via energy intake restriction, a low-fat diet, and exercise. The participants attended four initial group counseling sessions, followed by 12 biweekly intensive behavioral group sessions adapted from the Diabetes Prevention Program manual (18).

Across all three STRRIDE trials, exercise intensity and duration of aerobic exercise sessions were verified by direct supervision and/or with the use of downloadable heart rate monitoring (Polar Electro, Woodbury, NY). Resistance training sessions were verified by direct supervision and/or the FitLinxx Strength Training Partner (FitLinxx, Norwalk, CT). The Training Partner automatically sent data from each session to the FitLinxx server computer.

Anthropometrics

All anthropometric measurements were performed by trained study staff. Participants underwent measures at baseline and post-intervention. Height and body weight were measured in light clothing with shoes removed. Body weight was assessed using a calibrated digital scale to the nearest 0.1 kg (Scale 5005; ScaleTronix Inc., Wheaton, IL). The average of three weights taken over 2 wk on different days was used for each time point. Height was measured using a stadiometer to the nearest 0.5 cm. Body mass index was calculated as weight (in kilograms) divided by height (in meters) squared. Waist circumference was measured with a heavy-duty inelastic fiberglass tape that was calibrated against a metal tape measure to ensure accuracy. Participants stood with legs parallel and shoulder-width apart. Waist circumference was measured at the minimal waist (smallest horizontal circumference above the umbilicus and below the xiphoid process). Circumferences were taken with the tape placed directly on the skin (not over clothing). A third check of the waist circumference measure was conducted when the first two attempts were $\geq$0.7 cm apart. The intraobserver and interobserver variabilities were both 0.99 for minimal waist circumference. The measurement coefficient of variability was 0.57% for minimal waist circumference.

Body Composition

At the Duke University clinical site, body composition was assessed using either the Jackson–Pollock equation from skinfolds (STRRIDE I and STRRIDE AT/RT) or BOD POD air displacement plethysmography method (STRRIDE AT/RT and STRRIDE-PD; Life Measurement, Concord, CA). At the ECU clinical site, body composition was assessed using the Jackson–Pollock equation from skinfolds. In STRRIDE I and STRRIDE AT/RT, body composition was determined using the sum of four skinfolds measured with Lange calipers (Beta Technology Inc, Cambridge, MD) and the sex-specific formulas of Jackson and Pollock (19). Skinfolds included triceps (vertical fold; on the posterior midline of the upper arm, halfway between the acromion and olecranon processes, with the arm held freely to the side of the body), suprailiac (diagonal fold; in line with the natural angle of the iliac crest taken in the anterior axillary line immediately superior to the iliac crest), abdominal (vertical fold; 2 cm to the right side of the umbilicus), and thigh (vertical fold; on the anterior midline of the thigh midway between the proximal border of the patella and the inguinal crease (hip)). Percent body fat calculated from either BOD POD or Jackson–Pollock was converted into a *z*-score to standardize across men and women.

Computed tomography (CT) scans were performed by a radiological technologist who was blinded to the participant's study status on a GE CT/I (GE Medical Systems, Milwaukee, WI). After obtaining a digital frontal scout radiograph of the abdomen, a single 10-mm-thick axial section was performed at the level of the L-4 pedicle. CT scans were analyzed using Slice-O-Matic software (TomoVision, Quebec, Canada) to determine the surface area of the visceral and subcutaneous adipose tissue. A thorough description of the CT methods has been reported elsewhere (20,21).

Cardiorespiratory Fitness, Blood Pressure, and Heart Rate

Maximal cardiopulmonary exercise tests were conducted on all participants before the start of the intervention period. All tests were performed using a treadmill and Parvo Medics TrueOne 2400 metabolic system (Sandy, UT). Peak oxygen consumption ($\dot{V}O_{2peak}$; relative and absolute) was calculated as the average of the two greatest consecutive values within the last 90 s of exercise. Given that women have a lower $\dot{V}O_{2peak}$ compared with men, a *z*-score was generated to remove this possible confounding factor in the model. The peak respiratory exchange ratio was the single greatest value during exercise. Maximal heart rate was determined by staff review of the 12-lead electrocardiogram (GE CASE P2 System; GE

Medical Systems) printout at peak exercise. Resting blood pressure and heart rate measurements were taken manually before the maximal exercise test.

Plasma Lipids and Fasting Glucose and Insulin

Participants were asked to eat their normal diet the evening before the intervention followed by an overnight fast before the baseline blood collection. Glucose, insulin, HDL cholesterol, LDL cholesterol, and triglycerides were measured with a Beckman-Coulter DxC600 clinical analyzer (Brea, CA).

36-Item Short Form Health Survey

The 36-Item Short Form Health Survey (SF-36) was assessed before the intervention period as a measure of self-perceived physical and mental health over the prior 4 wk. The 36-item survey is scored in eight domains: physical functioning, role-physical, bodily pain, general health, vitality, social functioning, role-emotional, and mental health. The physical component score comprises the following four domains: physical functioning, role-physical, bodily pain, and general health. The mental component score comprises the following four domains: role-emotional, social functioning, vitality, and mental health. The SF-36 is valid and reliable, and there are standardized norms available for comparative purposes (22,23). Participants' raw scores were converted into scale scores ranging from 0 to 100, with greater scores representing better health-related quality of life or greater functioning for all scales (24). The SF-36 was scored by assessors blinded to participant group assignment.

Satisfaction with Physical Function and Appearance Survey

The Satisfaction with Physical Function and Appearance survey was used to measure participant-perceived satisfaction with physical function (SPF) and appearance (SPA) before the intervention period. This survey has been validated in several randomized controlled trials assessing health-related quality of life and physical activity participation (25,26). This nine-question survey contains five questions on physical function and four questions on physical appearance. Participants answered the following questions (question number in parentheses) regarding physical function: "Over the past four weeks, how satisfied have you been with (1) your overall level of physical fitness? (2) the muscle strength in your legs? (3) your level of endurance or stamina? (5) your overall level of energy? (6) your physical ability to do what you want or need to do?" The following questions were asked regarding physical appearance: "Over the past four weeks, how satisfied have you been with (4) your muscle tone? (7) your weight? (8) your shape? (9) your overall physical appearance?" Each item was rated on a 7-point Likert scale ranging from −3 to +3 with the following terms: very dissatisfied (−3), somewhat dissatisfied (−2), a little dissatisfied (−1), neither (0), a little satisfied (+1), somewhat satisfied (+2), and very satisfied (+3). Questions 1, 2, 3, 5, and 6 were averaged together to generate the SPF score. Similarly, questions 4, 7, 8, and 9 were averaged together to generate the SPA score. Greater scores indicate greater satisfaction with physical function and/or appearance. The Satisfaction with Physical Function and Appearance survey was also scored by blinded assessors.

Pittsburgh Sleep Quality Index

The Pittsburgh Sleep Quality Index (PSQI) survey was assessed before the intervention period as a measure of self-perceived sleep quality (27). The nine-item survey is scored into the following seven components, with scores ranging from 0 to 3: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction. The global PSQI comprises the sum of the seven components, with the score ranging from 0 to 21. The PSQI is valid and reliable, and there are standardized norms available for comparative purposes (27). Greater scores represent worse self-rated sleep quality or more severe difficulty with sleep (27). The PSQI was scored by assessors blinded to participant group assignment.

Adherence

Percent of aerobic training adherence was calculated by dividing weekly minutes of exercise completed after the ramp period by weekly minutes of exercise prescribed after the ramp period times 100 (10):

$$\frac{\text{Weekly minutes of exercise completed}}{\text{Weekly minutes of exercise prescribed}} \times 100$$

Percent of resistance training adherence was calculated by dividing weekly total sets completed by weekly total sets prescribed after the ramp period times 100 (10):

$$\frac{\text{Total weekly sets of resistance exercise completed}}{\text{Total weekly sets of resistance exercise prescribed}} \times 100$$

Statistical Analysis

These secondary analyses aimed to identify demographic, clinical, and psychosocial predictors of exercise intervention adherence. Data were analyzed using R/RStudio V4.2.1 (Boston, MA). All assumptions, including normality, required for regression analysis were assessed before modeling. Missing data among the covariates were filled in using multiple imputation. Thirty-eight demographic, clinical, and psychosocial measures were considered in developing three separate models: 1) clinical plus demographic factors, 2) psychosocial factors alone, and 3) all measures (Supplemental Content 1 and 2, tables, include all possible variables imputed in the model selection algorithm; http://links.lww.com/TJACSM/A223 and http://links.lww.com/TJACSM/A224). As previously mentioned, adherence was calculated as a continuous variable of total mean percent adherence. A backward bootstrapped selection algorithm using 1000 bootstrapped samples was performed for variable selection of each model. Multiple linear regression for each model was conducted following the variable selection technique. Because the variable in the present study was not the primary outcome variable for the STRRIDE trials, there were no *a priori* power calculations.

RESULTS

For these secondary analyses, 947 participants had baseline demographic and clinical variables available, and 561 participants had psychosocial variables available. Table 2 shows baseline demographic characteristics for the combined STRRIDE cohort. Participants were on average 52.9 ± 9.3 yr old, women (56.1%), and White (76.4%). The mean percent adherence for all three STRRIDE trials was 80.1% ± 27.8%. Fig. 1 displays

TABLE 2.
Baseline Clinical, Demographic, and Psychosocial Characteristics.

Variable	Mean (SD)
Clinical predictors (*n*)	947
Sex, female, *n* (%)	532 (56.1)
Race, White, *n* (%)	724 (76.4)
Age, yr	52.9 (9.3)
Average percent adherence	80.1 (27.8)
Minimal waist circumference, cm	97.1 (9.6)
Percent body fat	36.5 (9.3)
VAT, cm^2	174.0 (75.2)
SAT, cm^2	321.9 (104.8)
Relative $\dot{V}O_{2peak}$, $mL \cdot kg^{-1} \cdot min^{-1}$	26.2 (5.9)
Mean heart rate, bpm	171.1 (15.3)
Time to exhaustion, s	692.7 (198.8)
Respiratory exchange ratio	1.1 (0.1)
Fasting glucose, $mmol \cdot L^{-1}$	5.4 (0.7)
Fasting insulin, $pmol \cdot L^{-1}$	53.0 (35.0)
HDL-c, $mg \cdot dL^{-1}$	50.6 (15.1)
LDL-c, $mg \cdot dL^{-1}$	136.3 (28.5)
Triglycerides, $mg \cdot dL^{-1}$	143.0 (87.5)
Systolic blood pressure, mm Hg	124.5 (14.7)
Diastolic blood pressure, mm Hg	79.2 (9.5)
Psychosocial predictors (*n*)	561
Satisfaction with physical function	−0.4 (1.6)
Satisfaction with physical appearance	−1.4 (1.5)
SF-36: physical functioning	79.0 (15.7)
SF-36: role-physical	83.9 (21.7)
SF-36: bodily pain	77.1 (19.5)
SF-36: general health	67.7 (18.6)
SF-36: physical component score	74.7 (7.8)
SF-36: vitality	53.7 (18.4)
SF-36: social functioning	64.8 (19.1)
SF-36: role-emotional	86.6 (19.4)
SF-36: mental health	74.9 (18.3)
SF-36: mental component score	58.1 (7.6)
PSQI: sleep quality	0.9 (0.8)
PSQI: sleep latency	0.9 (0.9)
PSQI: sleep duration	0.6 (0.7)
PSQI: habitual sleep efficiency	0.5 (0.8)
PSQI: sleep disturbances	1.3 (0.6)
PSQI: use of sleeping medication	0.6 (1.1)
PSQI: daytime dysfunction	0.8 (0.7)
PSQI: global score	5.7 (3.2)

HDL-c, HDL cholesterol; LDL-c, LDL cholesterol; SAT, subcutaneous adipose tissue; VAT, visceral adipose tissue.

waterfall plots representing each individual mean percent adherence across the three STRRIDE trials.

Model 1: Clinical and Demographic Measures Only

Backward selection with clinical and demographic measures (n = 947) identified an adherence model with 12 predictor variables explaining approximately 16.7% of the variance (Table 3). Lesser fasting glucose (partial R^2 = 0.032), greater fasting insulin (partial R^2 = 0.025), greater triglycerides (partial R^2 = 0.021), and greater resting heart rates (partial R^2 = 0.017) predicted greater intervention adherence. Fasting glucose explained the greatest amount of variance in exercise adherence for this model.

Model 2: Psychosocial Measures Only

Backward selection with psychosocial measures (n = 561) identified an adherence model with 11 predictor variables explaining approximately 19.3% of the variance (Table 3). Greater SF-36 physical component score (partial R^2 = 0.087), lesser SF-36 self-rated bodily pain (partial R^2 = 0.046), lesser SF-36 mental component score (partial R^2 = 0.046), greater SF-36 vitality (partial R^2 = 0.040), and lesser SF-36 physical functioning (partial R^2 = 0.033) predicted greater intervention adherence. The SF-36 physical component score explained the greatest amount of variance in exercise adherence.

Model 3: All Measures

Backward selection with demographic, clinical, and psychosocial measures (n = 561) identified an adherence model with 20 predictor variables explaining approximately 22.1% of the variance (Table 4). Greater SF-36 physical component score (partial R^2 = 0.089), lesser SF-36 bodily pain (partial R^2 = 0.051), lesser SF-36 mental component score (partial R^2 = 0.042), lesser SF-36 physical functioning (partial R^2 = 0.038), and greater SF-36 vitality (partial R^2 = 0.038) predicted greater intervention adherence. SF-36 physical component score remained the strongest predictor variable explaining the greatest variance in adherence.

DISCUSSION

Among previously sedentary adults with dyslipidemia or prediabetes, baseline clinical, demographic, and psychosocial measures explained approximately 22% of the variance in

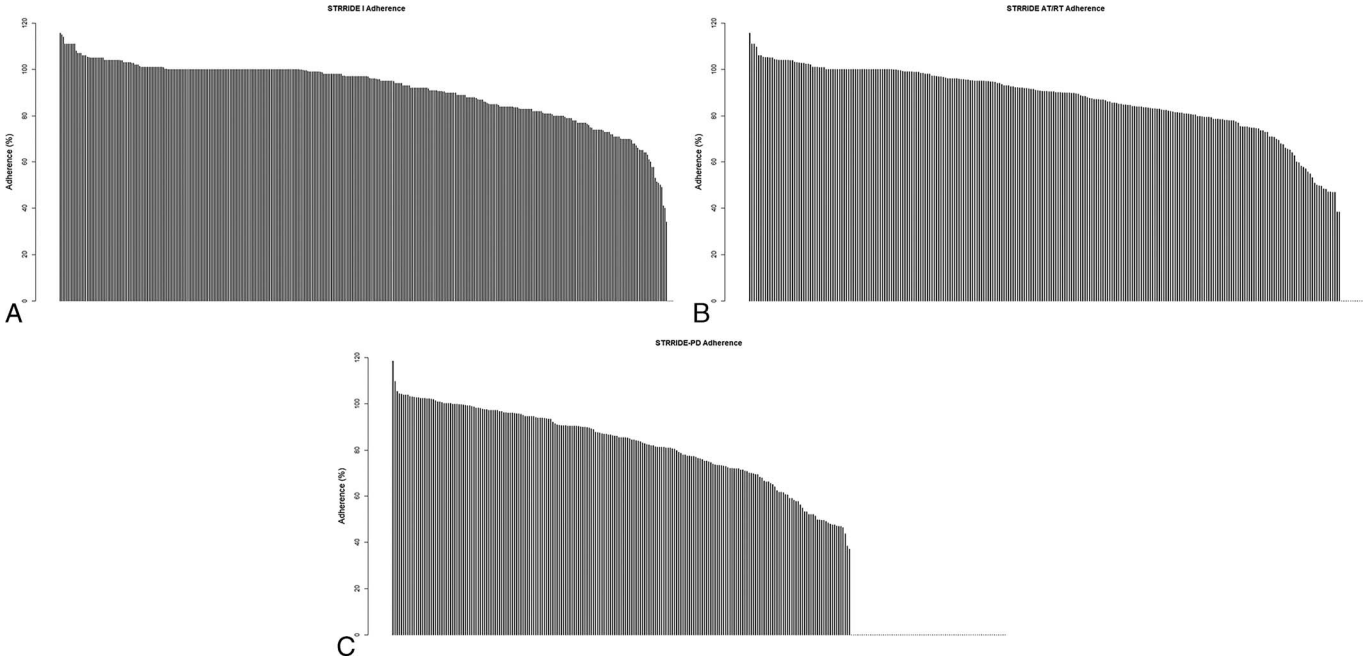

Figure 1: Distribution of individual mean percent adherence across each of the STRRIDE trials. Each bar represents an individual participant's percent adherence. A, STRRIDE I; B, STRRIDE AT/RT; C, STRRIDE-PD.

exercise intervention adherence. In the model using demographic and clinical measures only, lesser fasting glucose concentrations and greater fasting insulin concentrations were the strongest predictors of greater adherence. For both the psychosocial measures only and all measures models, a greater physical component score was the strongest predictor of greater intervention adherence. Physical component score was the only variable to account for >8% of the variance in adherence in the psychosocial measures only and all measures models, and the only variable accounting for >5% of the variance in adherence in any model. Moreover, the addition of psychosocial measures to clinical and demographic measures increased the prediction variance by 6%. These findings highlight the importance of self-reported participant outcomes, specifically self-rated physical functioning, limitations caused by physical problems, bodily pain, and perceived health in general—all of which comprise the physical component score—when targeting adherence to exercise interventions.

Although we have included a wide range of demographic, clinical, and psychosocial variables in the predictive models, the inability of these variables to predict more than 22% of the variance in adherence is disappointing but not surprising given previous findings. The Heart Failure: A Controlled Trial Investigating Outcomes of Exercise Training trial was a 12-month exercise intervention in individuals with heart failure (28–30). The study assessed baseline demographic and clinical variables as predictors of exercise intervention adherence for months 1–3 and 10–12 (31). In the multivariable model for months 1–3, younger age, lower income, more severe mitral valve regurgitation, shorter 6-min walk distance, lower exercise capacity, and Black or African American race predicted poorer intervention adherence. No variable accounted for >2% of the variance in adherence, and the adjusted R^2 for the final model was 0.14. There was a similar R^2 for the multivariable model for months 10–12, with adherence during months 1–3 being the strongest predictor of adherence in this model (31). Baseline clinical and demographic variables provide little information for identifying patients with heart failure who are at risk for poor adherence to exercise interventions. In the present study in a previously sedentary adult population with dyslipidemia or prediabetes, lesser fasting glucose and greater fasting insulin were the strongest clinical predictors of adherence. When psychosocial measures were included with demographic and clinical variables, the final model explained the greatest amount of variance in intervention adherence (22%).

In a 2-yr randomized trial, Findorff and colleagues (32) assessed baseline demographic, clinical, psychosocial, and cognitive measures as predictors of adherence to a home-based exercise intervention involving walking and balance exercises in older women. In the final model, lesser body mass index, less depression, a lower number of chronic conditions, greater self-efficacy, and greater self-rated physical functioning significantly predicted greater adherence. However, the final model was only able to explain approximately 19% of the variance in adherence (32). Although we found different significant demographic, clinical, and psychosocial predictors of intervention adherence, our overall model explained a comparable amount of variance in adherence, suggesting that the ability of baseline demographic, clinical, and psychosocial measures to predict adherence across different studies conducted in different populations is consistent.

Current research involving predictors of exercise intervention adherence has predominantly focused on these easily measured demographic, clinical, cognitive, and/or psychosocial factors (7,31–34), leaving out numerous other factors—such as genetic and metabolic predisposition and personality type—that may influence an individual's adherence behavior. Future research should explore factors representative of inherent predisposition, including but not limited to molecular factors and personality type, as predictors of exercise intervention

TABLE 3.
Multiple Linear Regression Following Variable Selection of Demographic and Clinical Predictors Only and Psychosocial Predictors Only of Greater Exercise Intervention Adherence in the STRRIDE Trials.

Variable	Estimate (β)	95% CI	P	Partial R^2
Demographic and clinical variables				
Race				0.010
Black	−2.01	−15.79 to 11.7	0.77	
White	4.98	−8.45 to 18.43	0.47	
Age	0.31	0.07 to 0.55	0.01	0.007
Minimal waist circumference	−0.31	−0.51 to −0.11	0.002	0.010
Time to exhaustion from CPET	0.02	0.01 to 0.04	0.002	0.011
$\dot{V}O_{2peak}$ z-score	−3.08	−6.16 to 0.01	0.05	0.004
Heart rate	0.31	0.16 to 0.47	<0.001	0.017
Respiratory exchange ratio	21.21	−2.16 to 44.59	0.08	0.003
Systolic blood pressure	0.12	0.005 to 0.23	0.04	0.004
Fasting glucose	−0.44	−0.59 to −0.28	<0.001	0.032
Fasting insulin	0.82	0.49 to 1.15	<0.001	0.025
LDL-c	0.10	0.04 to 0.16	0.002	0.010
Triglycerides	0.05	0.03 to 0.07	<0.001	0.021
Adjusted R^2				0.167
Psychosocial variables				
Satisfaction with physical function	1.75	0.02 to 3.48	0.048	0.007
SF-36				
Physical functioning	−0.58	−0.84 to −0.31	<0.0001	0.033
Role-physical	−0.33	−0.56 to −0.10	0.004	0.014
Bodily pain	−0.38	−0.52 to −0.23	<0.0001	0.046
General health	−0.32	−0.52 to −0.13	0.001	0.019
Physical component score	3.73	2.72 to 4.74	<0.0001	0.087
Vitality	0.39	0.23 to 0.54	<0.0001	0.040
Role-emotional	0.29	0.03 to 0.54	0.03	0.009
Mental health	0.54	0.25 to 0.83	<0.0001	0.024
Mental component score	−2.75	−3.80 to −1.70	<0.0001	0.046
PSQI				
Sleep duration	4.49	1.29 to 7.69	0.006	0.014
Adjusted R^2				0.193

$\dot{V}O_{2peak}$ was converted into a z-score to standardize across men and women.
CI, confidence interval; CPET, cardiopulmonary exercise test; LDL-c, LDL cholesterol.

TABLE 4.
Multiple Linear Regression After Variable Selection of Clinical, Demographic, and Psychosocial Predictors of Greater Exercise Intervention Adherence in the STRRIDE Trials.

Variable	Estimate (β)	95% CI	P	Partial R^2
Sex, male	−6.45	−13.93 to 1.02	0.09	0.005
Race				0.009
Black	−10.37	−29.99 to 9.25	0.30	
White	−3.75	−22.78 to 15.29	0.70	
Percent body fat z-score	−2.46	−5.14 to 0.24	0.07	0.006
$\dot{V}O_{2peak}$ z-score	2.81	−0.72 to 6.35	0.12	0.005
Respiratory exchange ratio	26.65	−7.15 to 60.45	0.12	0.004
HDL-c	0.18	−0.02 to 0.38	0.08	0.006
Triglycerides	0.04	0.0001 to 0.07	0.005	0.007
Systolic blood pressure	0.31	0.10 to 0.52	0.004	0.015
Diastolic blood pressure	−0.39	−0.70 to −0.07	0.02	0.011
Satisfaction with physical function	1.95	0.22 to 3.68	0.03	0.009
SF-36				
Physical functioning	−0.63	−0.90 to −0.36	<0.0001	0.038
Role-physical	−0.30	−0.53 to −0.08	0.009	0.013
Bodily pain	−0.39	−0.54 to −0.25	<0.0001	0.051
General health	−0.30	−0.50 to −0.10	0.004	0.016
Physical component score	3.76	2.74 to 4.79	<0.0001	0.089
Vitality	0.38	0.22 to 0.54	<0.0001	0.038
Role-emotional	0.31	0.05 to 0.56	0.02	0.010
Mental health	0.51	0.22 to 0.81	0.0007	0.021
Mental component score	−2.64	−3.73 to −1.57	<0.0001	0.042
PSQI				
Sleep duration	4.09	0.64 to 7.11	0.01	0.012
Adjusted R^2				0.221

$\dot{V}O_{2peak}$ and percent body fat were converted into z-scores to standardize across men and women.
CI, confidence interval; HDL-c, HDL cholesterol.

adherence, not only to determine if the explained variance in adherence can be improved but also because these factors represent certain behaviors or the likelihood to develop particular diseases. Future research should investigate the optimal combination of all measured factors, from clinical and psychosocial to genetic and metabolic, to improve predictive power of intervention adherence behavior. The development of an optimal predictive model is important not only for identifying key factors of adherence behavior but also for identifying individuals who are at greatest risk of poor exercise intervention adherence. Only once these at-risk individuals are able to be identified can targeted strategies and interventions be developed to optimize exercise adherence and ultimately improve health across the life span.

Strengths of this analysis include a large cohort with sufficient power to assess predictors of adherence, a well-phenotyped population, and a randomized controlled trial study design. However, this study and these secondary analyses do not come without limitations. The definition of adherence does not incorporate all aspects of the exercise prescriptions, such as frequency, duration, intensity, and mode. Because individuals who participated the STRRIDE trials were initially motivated to join an exercise intervention, findings may not be more broadly generalizable. Lastly, these trials were limited to previously sedentary adults

with overweight or obesity and dyslipidemia or prediabetes and may not be generalizable to exercise interventions in other populations.

In individuals with dyslipidemia or prediabetes, baseline demographic, clinical, and psychosocial measures explained approximately 22% of the variance in exercise intervention adherence. Only the physical component score, reflecting overall self-rated physical function and health, accounted for >8% of the variance in adherence in any model. Future research should investigate other potential factors beyond those examined in the present study to enhance the prediction of exercise intervention adherence.

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REFERENCES

1. Physical Activity Guidelines Advisory Committee. *2018 Physical Activity Guidelines Advisory Committee Scientific Report*. Washington (DC): U.S. Department of Health and Human Services; 2018. 779 p.
2. Paluch AE, Bajpai S, Bassett DR, et al. Daily steps and all-cause mortality: A meta-analysis of 15 international cohorts. *Lancet Public Health*. 2022;7(3): e219–28.
3. Pojednic R, D'Arpino E, Halliday I, Bantham A. The benefits of physical activity for people with obesity, independent of weight loss: A systematic review. *Int J Environ Res Public Health*. 2022;19(9):4981.
4. Lavie CJ, Ozemek C, Carbone S, et al. Sedentary behavior, exercise, and cardiovascular health. *Circ Res*. 2019;124(5):799–815.
5. Aune D, Norat T, Leitzmann M, et al. Physical activity and the risk of type 2 diabetes: A systematic review and dose-response meta-analysis. *Eur J Epidemiol*. 2015;30(7):529–42.
6. Jakicic JM, Powell KE, Campbell WW, et al. Physical activity and the prevention of weight gain in adults: A systematic review. *Med Sci Sports Exerc*. 2019; 51(6):1262–9.
7. Roumen C, Feskens EJM, Corpeleijn E, et al. Predictors of lifestyle intervention outcome and dropout: The SLIM study. *Eur J Clin Nutr*. 2011;65(10):1141–7.
8. Groeneveld IF, Proper KI, van der Beek AJ, et al. Factors associated with non-participation and drop-out in a lifestyle intervention for workers with an elevated risk of cardiovascular disease. *Int J Behav Nutr Phys Act*. 2009;6:80.
9. Vermunt PWA, Milder IEJ, Wielaard F, et al. Implementation of a lifestyle intervention for type 2 diabetes prevention in Dutch primary care: Opportunities for intervention delivery. *BMC Fam Pract*. 2012;13:79.
10. Collins KA, Huffman KM, Wolever RQ, et al. Determinants of dropout from and variation in adherence to an exercise intervention: The STRRIDE randomized trials. *Transl J Am Coll Sports Med*. 2022;7(1):e000190.
11. Dishman RK, Chubb M. Determinants of participation in physical activity. In: Bouchard C, Shephard RJ, Stephens T, et al, editors. Exercise, Fitness, and Health: A Consensus of Current Knowledge: Proceedings of the International Conference on Exercise, Fitness and Health; 1988 May 29–June 3; Toronto, Canada. Champaign (IL): Human Kinetics Publishers; 1990. pp. 75–108.
12. Dishman RK, Sallis JF, Orenstein DR. The determinants of physical activity and exercise. *Public Health Rep*. 1985;100(2):158–71.
13. King AC, Blair SN, Bild DE, et al. Determinants of physical activity and interventions in adults. *Med Sci Sports Exerc*. 1992;24(Suppl 6):S221–36.
14. Burgess E, Hassmén P, Pumpa KL. Determinants of adherence to lifestyle intervention in adults with obesity: A systematic review. *Clin Obes*. 2017;7(3): 123–35.
15. Kraus WE, Torgan CE, Duscha BD, et al. Studies of a Targeted Risk Reduction Intervention through Defined Exercise (STRRIDE). *Med Sci Sports Exerc*. 2001;33(10):1774–84.
16. Slentz CA, Bateman LA, Willis LH, et al. Effects of aerobic vs. resistance training on visceral and liver fat stores, liver enzymes, and insulin resistance by HOMA in overweight adults from STRRIDE AT/RT. *Am J Physiol Endocrinol Metab*. 2011;301(5):E1033–9.
17. Slentz CA, Bateman LA, Willis LH, et al. Effects of exercise training alone vs a combined exercise and nutritional lifestyle intervention on glucose homeostasis in prediabetic individuals: A randomised controlled trial. *Diabetologia*. 2016;59(10):2088–98.
18. Knowler WC, Barrett-Connor E, Fowler SE, et al. Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. *N Engl J Med*. 2002; 346(6):393–403.
19. Jackson AS, Pollock ML. Practical assessment of body composition. *Phys Sportsmed*. 1985;13(5):76–90.
20. Slentz CA, Duscha BD, Johnson JL, et al. Effects of the amount of exercise on body weight, body composition, and measures of central obesity: STRRIDE—a randomized controlled study. *Arch Intern Med*. 2004;164(1):31–9.
21. Willis LH, Slentz CA, Bateman LA, et al. Effects of aerobic and/or resistance training on body mass and fat mass in overweight or obese adults. *J Appl Physiol (1985)*. 2012;113(12):1831–7.
22. Ware JE, Kosinski M, Dewey JE, Gandek B. *SF-36 Health Survey: Manual and Interpretation Guide*. Lincoln (RI): Quality Metric Inc.; 2000.
23. Ware JE Jr., Sherbourne CD. The MOS 36-Item Short-Form Health Survey (SF-36): I. Conceptual framework and item selection. *Med Care*. 1992;30(6): 473–83.
24. Ware JE, Kosinski MA, Keller SK. *SF-36 Physical and Mental Health Summary Scales: A User's Manual*. Boston (MA): The Health Institute; 1994.
25. Ray K, Hector L, Lynes L, et al. Assessment of satisfaction with physical fitness in kidney transplant recipients 38. *Med Sci Sports Exerc*. 1996;28(5):7.
26. Reboussin BA, Rejeski WJ, Martin KA, et al. Correlates of satisfaction with body function and body appearance in middle-and older aged adults: The Activity Counseling Trial (ACT). *Psychol Health*. 2000;15(2):239–54.
27. Buysse DJ, Reynolds CF 3rd, Monk TH, et al. The Pittsburgh Sleep Quality Index: A new instrument for psychiatric practice and research. *Psychiatry Res*. 1989;28(2):193–213.
28. Whellan DJ, O'Connor CM, Lee KL, et al. Heart Failure and A Controlled Trial Investigating Outcomes of Exercise TraiNing (HF-ACTION): design and rationale. *Am Heart J*. 2007;153(2):201–11.
29. O'Connor CM, Whellan DJ, Lee KL, et al. Efficacy and safety of exercise training in patients with chronic heart failure: HF-ACTION randomized controlled trial. *JAMA*. 2009;301(14):1439–50.
30. Flynn KE, Piña IL, Whellan DJ, et al. Effects of exercise training on health status in patients with chronic heart failure: HF-ACTION randomized controlled trial. *JAMA*. 2009;301(14):1451–9.
31. Collins KA, Reeves GR, Miller NH, et al. Clinical Predictors of Adherence to Exercise Training Among Individuals With Heart Failure: THE HF-ACTION STUDY. *J Cardiopulm Rehabil Prev*. 2022;43(3):205–213.
32. Findorff MJ, Wyman JF, Gross CR. Predictors of long-term exercise adherence in a community-based sample of older women. *J Womens Health (Larchmt)*. 2009;18(11):1769–76.
33. Cooper LB, Mentz RJ, Sun J-L, et al. Psychosocial factors, exercise adherence, and outcomes in heart failure patients. *Circ Heart Fail*. 2015;8(6): 1044–51.
34. Nelson MB, Gilbert ON, Duncan PW, et al. Intervention adherence in REHAB-HF: predictors and relationship with physical function, quality of life, and clinical events. *J Am Heart Assoc*. 2022;11(11):e024246.