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Determinants of Dropout from and Variation in Adherence to an Exercise Intervention: The STRRIDE Randomized Trials

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ABSTRACT

Purpose: This study aimed to characterize the timing and self-reported determinants of exercise dropout among sedentary adults with overweight or obesity. We also sought to explore variations in adherence among individuals who completed a 6- to 8-month structured exercise intervention. **Methods:** A total of 947 adults with dyslipidemia (STRRIDE I, STRRIDE AT/RT) or prediabetes (STRRIDE-PD) were enrolled to either control or to 1 of 10 exercise interventions, ranging from doses of 8 to 23 $kcal \cdot kg^{-1} \cdot wk^{-1}$, intensities of 50% to 75% $\dot{V}O_2$ peak, and durations of 6 to 8 months. Two groups included resistance training, and one included dietary intervention (7% weight loss goal). Dropout was defined as an individual who withdrew from the study because of a variety of determinants. Timing of intervention dropout was defined as the last session attended and categorized into phases. Exercise training adherence was calculated by dividing weekly minutes or total sets of exercise completed by weekly minutes or total sets of exercise prescribed. General linear models were used to characterize the associations between timing of dropout and determinant category. **Results:** Compared with exercise intervention completers ($n = 652$), participants who dropped out ($n = 295$) were on average non-White (98% vs 80%, $P < 0.01$), had higher body mass index (31.0 vs 30.2 $kg \cdot m^{-2}$, $P < 0.01$), and were less fit at baseline (25.0 vs 26.7 $mL \cdot kg^{-1} \cdot min^{-1}$, $P < 0.01$). Of those who dropped out, 67% did so before the start of or while ramping up to the prescribed exercise volume and intensity. The most commonly reported reason for dropout was lack of time (40%). Notably, among individuals who completed the ramp training period, subsequent exercise intervention adherence did not waiver over the ensuing 6–8 months of training. **Conclusions:** These findings are some of the first to delineate associations between the timing of dropout and dropout determinants, providing guidance for future exercise interventions to better support individuals at risk for dropout.

INTRODUCTION

Participation in exercise reduces the risk of cardiovascular disease, type 2 diabetes, certain cancers, obesity, depression, and anxiety (1). Despite these well-known health benefits, nearly 80% of adults do not meet the recommended amount of exercise for either aerobic or resistance training (1). Furthermore, among individuals motivated to enroll and complete exercise training through a lifestyle intervention trial, 20%–30% are unable to maintain this behavior change after trial completion (2–7).

There are numerous, codified personal and environmental determinants influencing exercise participation and maintenance. The most common reasons participants give for not regularly participating in exercise include lack of time, caregiving responsibilities, lack of a safe environment to exercise, weather, transportation issues, and lack of social support (8–11). In addition to understanding exercise cessation causes (i.e., why), identifying exercise cessation timing (i.e., when) is also important to best improve uptake of future interventions. One challenge to understanding exercise cessation

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is the lack of a uniform definition for those discontinuing a regular exercise program—herein termed "dropouts"—and a lack of researcher follow-up of "dropouts" (12). Although data suggest most individuals dropout within the first 6 months of initiating regular exercise (12), clear gaps remain regarding dropout definitions and timing within the first 6 months of structured exercise; to the authors' knowledge, little research has investigated the association between exercise intervention dropout determinants and timing of dropout. In addition, among individuals maintaining participation in a structured exercise intervention, little to no research examines the variation of adherence to prescribed exercise over the course of an intervention. Delineating the timing and determinants of exercise dropout and assessing variation in adherence hold important implications for the development of targeted interventions to improve retention and long-term maintenance of treatment gains. Possibly, participants who dropout early on in the intervention may not have experienced the full benefits of treatment before study withdrawal. Thus, identifying different "dropout phenotypes" may prove helpful in developing tailored remediation strategies—such as more gradual training titration or motivational enhancement—to enhance treatment engagement and retention.

The three Studies of a Targeted Risk Reduction Intervention through Defined Exercise (STRRIDE) randomized trials examined the differential effects of exercise amount, mode, and intensity on cardiometabolic health; each of the STRRIDE studies clearly defined exercise intervention dropout and adherence. Thus, the STRRIDE trials offer the opportunity to explore dropout determinants, dropout timing, and their association among sedentary adults with overweight or obesity. Moreover, these studies allow for examination of adherence variation in participants who completed 6- to 8-month structured exercise interventions.

METHODS

Study Participants

Exercise intervention dropout was assessed in participants from STRRIDE I (5), STRRIDE AT/RT (6), and STRRIDE-PD (7). STRRIDE I (1999–2003) and STRRIDE AT/RT (2004–2008) enrolled previously sedentary men and women with overweight or obesity and mild-to-moderate dyslipidemia (classified by LDL-cholesterol 130–190 $mg \cdot dL^{-1}$ or HDL-cholesterol ≤40 $mg \cdot dL^{-1}$ for men and <45 $mg \cdot dL^{-1}$ for women). STRRIDE-PD (2009–2012) enrolled previously sedentary men and women with overweight or obesity and prediabetes (defined by two consecutive fasting glucose concentrations ≥95 to <126 $mg \cdot dL^{-1}$ taken 1 wk apart). Participants were enrolled at either Duke University or East Carolina University (ECU).

Table 1 describes the randomized exercise intervention groups across each STRRIDE trial (5–7). Both STRRIDE I and AT/RT study protocols were approved by the institutional review boards at Duke University and ECU. The STRIDE-PD study protocol was approved by the institutional review board at Duke University. Participants provided both verbal and signed written informed consent.

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. The ramp period was followed by 6 additional months of 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, to allow gradual adaptation to their exercise prescription, participants underwent an 8- to 10-wk ramp period. The ramp period was followed by 5 to 6 additional 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, two sets during weeks 3–4, and built up to the three-set prescription on week 5.

In STRRIDE-PD, participants completed a 3-month inactive control period (run-in) before exercise intervention randomization. After randomization, to allow gradual adaptation to their exercise prescription, participants underwent a 10-wk ramp period; however, the total duration of the exercise intervention was 6 months, regardless of the duration 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 (13). This group was designed to achieve 7% weight loss via energy intake restriction, low-fat diet, and exercise. The participants attended four initial counseling sessions, followed by 12 biweekly intensive behavioral group sessions adapted from the Diabetes Prevention Program manual.

Across all three STRRIDE trials, exercise intensity and duration for aerobic exercise sessions were verified by direct supervision and/or with the use of downloadable heart rate monitors (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.

Dropout Definitions and Statistical Analyses

For dropout and adherence analyses, data were analyzed using JMP 15.0 (SAS Institute, Cary, NC). Baseline demographic characteristic (e.g., age, gender, race, etc.) differences between exercise intervention completers and dropouts were assessed using Fisher exact test, χ^2 test, or two-tailed *t*-test for independent groups. A P value of <0.05 was considered significant.

Dropout across the three STRRIDE studies was defined as an individual who withdrew from the study because of personal factors, was withdrawn from the study by the principal investigator (PI; i.e., participant wanted to lose weight), or was lost to follow-up. The following categories were created to define self-reported determinants for participant dropout: 1) lack of time, 2) transportation issue, 3) biopsy issue (*vastus lateralis* needle biopsies were performed at baseline and intervention conclusion), 4) changed mind, 5) health issue, 6) exacerbation of prior injury, 7) moved, 8) withdrawn by PI, and 9) lost to follow-up. Within the lack of time category, subcategories were generated to further clarify reasons for dropout,

TABLE 1.
Baseline Characteristics of STRRIDE Participants Who Completed the Intervention versus Those Who Dropped Out, and Description of STRRIDE I, AT/RT, and PD Randomized Intervention Groups.

	Completers	Dropout	*P*
Sample size, *n*	652	295	
Age, yr	52.9 (9.2)	53.0 (9.5)	0.9165
Female, %	54.1	60.3	0.0776*
Caucasian, %	80.4	67.5	<0.0001**
Body mass index, $kg \cdot m^{-2}$	30.2 (3.0)	31.0 (3.3)	0.0004**
Peak $\dot{V}O_2$, $mL \cdot kg^{-1} \cdot min^{-1}$	26.7 (5.8)	25.0 (6.0)	<0.0001**
Intervention Group	**Exercise Prescription**		
STRRIDE I			
Inactive control	—		
High-amount/vigorous-intensity	23 KKW or 20 $miles \cdot wk^{-1}$	65%–80% peak $\dot{V}O_2$	
Low-amount/vigorous-intensity	14 KKW or 12 $miles \cdot wk^{-1}$	65%–80% peak $\dot{V}O_2$	
Low-amount/moderate-intensity	14 KKW or 12 $miles \cdot wk^{-1}$	40%–55% peak $\dot{V}O_2$	
STRRIDE AT/RT			
Aerobic training (low-amount/vigorous-intensity)	14 KKW or 12 $miles \cdot wk^{-1}$	65%–80% peak $\dot{V}O_2$	
Resistance training	3 $d \cdot wk^{-1}$, 3 $sets \cdot day^{-1}$, 8–12 reps of 8 exercises		
Aerobic + resistance training	14 KKW or 12 $miles \cdot wk^{-1}$ at 65%–80% peak $\dot{V}O_2$ + 3 $d \cdot wk^{-1}$, 3 $sets \cdot day^{-1}$, 8–12 reps of 8 exercises		
STRRIDE-PD			
High-amount/vigorous-intensity	16 KKW or 13.8 $miles \cdot wk^{-1}$	65%–80% peak $\dot{V}O_2$	
High-amount/moderate-intensity	16 KKW or 13.8 $miles \cdot wk^{-1}$	40%–55% peak $\dot{V}O_2$	
Low-amount/moderate-intensity	10 KKW or 8.6 $miles \cdot wk^{-1}$	40%–55% peak $\dot{V}O_2$	
Combined lifestyle intervention	10 KKW or 8.6 $miles \cdot wk^{-1}$ at 40%–55% peak $\dot{V}O_2$ + diet to reduce 7% body weight		

Values are listed as mean (SD) unless otherwise indicated. Fisher exact test, χ^2 test, or independent *t*-test used to compare completers versus dropouts.
*$P < 0.1$.
**$P < 0.01$.
KKW, kilocalories per kilogram of body weight per week.

including 1) family, 2) family and work, 3) motivation, 4) general time, 5) travel, 6) travel and motivation, 7) work, 8) work and motivation, and 9) work and travel. Percentages were generated according to determinant categories and lack of time subcategories to describe the proportion of all dropouts who fell within each category. All Duke and ECU participants who dropped out were included in the denominators for each determinant category and lack of time subcategory.

Timing of intervention dropout was defined as the last attended session, whether an assessment or exercise session. Because of data from ECU not having been entered into an electronic database, we were unable to properly identify timing of intervention dropout among the ECU participants; thus, only individuals participating at the Duke site were included in analyses involving timing of exercise intervention dropout and the interaction between timing and dropout determinants. Based on the last attended visit, the timing of dropout was categorized into one of the following for description purposes:

> *Before exercise initiation:* 1) baseline visits, 2) run-in period;
> *During exercise participation:* 3) ramp period, 4) month 1 of the exercise intervention, 5) month 2, 6) month 3, 7) month 4, 8) month 5, 9) month 6, 10) month 7;
> *After exercise participation:* 11) post-intervention visits.

Number of individuals in each timing category was aggregated. Time to dropout of the study was used as the outcome variable for survival analysis, and an ANOVA was performed to determine if there was a difference in timing of dropout by determinant category. Survival curves were created to display these results. Because of small numbers, the following determinants were combined into one category labeled as "other": 1) transportation issue, 2) biopsy issue, 3) health issue, 4) exacerbation of preexisting injury, 5) moved, and 6) withdrawn by PI; our rationale was that the "other" reasons were not behavioral, but primarily determined by health or environmental issues. *Post hoc* analyses to compare individual dropout reasons were performed using the Tukey–Kramer adjustment.

Adherence Definitions and Statistical Analyses

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. Percent of resistance training adherence was calculated by dividing weekly total sets competed by weekly total sets prescribed after the ramp period. Mean percent adherence at each week of the intervention is displayed by randomized intervention group for each STRRIDE trial. This analysis excludes the control group from STRRIDE I as they were not prescribed exercise. Extra weeks were added onto the end of each STRRIDE intervention to provide an opportunity for participants to make up a week if they missed one during the intervention; therefore, a smaller sample is represented in the latter weeks of each percent adherence figure. All Duke and ECU participants who completed the exercise intervention were included in this analysis.

RESULTS

Dropout Findings

Of the 947 participants enrolled into one of the three STRRIDE randomized trials, 652 (69%) completed the exercise intervention and 295 (31%) dropped out of the trials. Table 1 displays baseline demographic characteristics for each group. Compared with exercise intervention completers, participants who dropped out were on average non-White (98% vs 80%, $P < 0.01$), had higher body mass index (31.0 vs 30.2 kg·m^{-2}, $P < 0.01$), and were less fit at baseline (25.0 vs 26.7 mL·kg^{-1}·min^{-1}; $P < 0.01$).

Figure 1A displays each categorical determinant for exercise intervention dropout with the percentage of participants who fell into each category. The most frequent barrier individuals reported as to why they dropped out from the STRRIDE interventions was lack of time (40%), followed by lost to follow-up (18%), exacerbation of prior injury (12%), health issue (10%), changed mind (9%), withdrawn by PI (5%), moved (3%), biopsy issues (2%), and transportation issue (1%). Although time was further broken down into subcategories, time in general (52%) was still the number one reason for dropout. Time subcategories and the percent of individuals who fell under each category are displayed in Figure 1B.

Of the 295 participants identified as STRRIDE intervention dropouts, 241 (82%) were recruited at the Duke site and were included in the analysis of dropout timing. Figure 2 displays dropout timing across all STRRIDE randomized trials. Approximately two-thirds (66%) of those who dropped out discontinued before intervention month 1; they dropped out either during baseline visits, the run-in period, or the ramp period. Figure 3 presents a survival curve displaying timing of exercise intervention dropout by four determinant categories (i.e., changed mind, lost to follow-up, time, and other) across all three STRRIDE trials. The ANOVA revealed a significant difference in timing of dropout by dropout determinant ($F = 4.62$, $P = 0.004$). *Post hoc* analyses revealed a significant difference among individuals who were lost to follow-up ($P = 0.009$) and those who reported a lack of time ($P = 0.003$) compared with individuals who changed their minds; those who changed their minds dropped out earlier during the study period compared with those in other determinant categories.

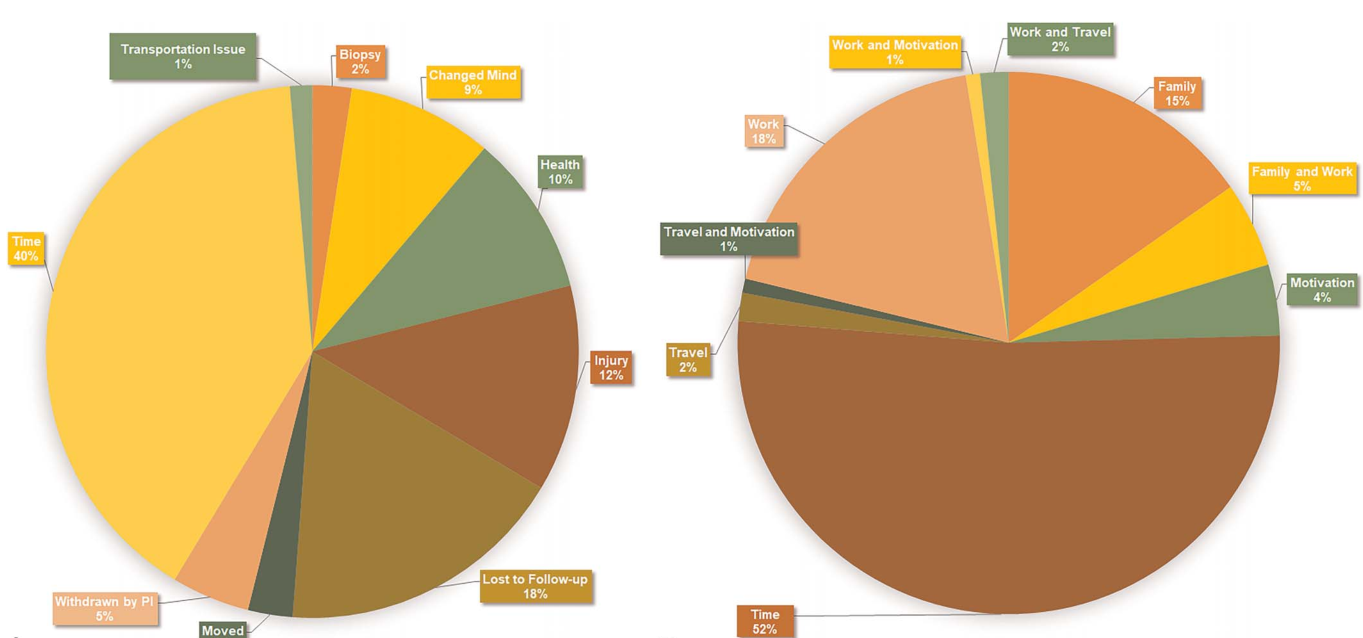

Figure 1: Determinants of exercise intervention dropout. A, Categorical determinants of dropout. B, Time subcategorical determinants for dropout.

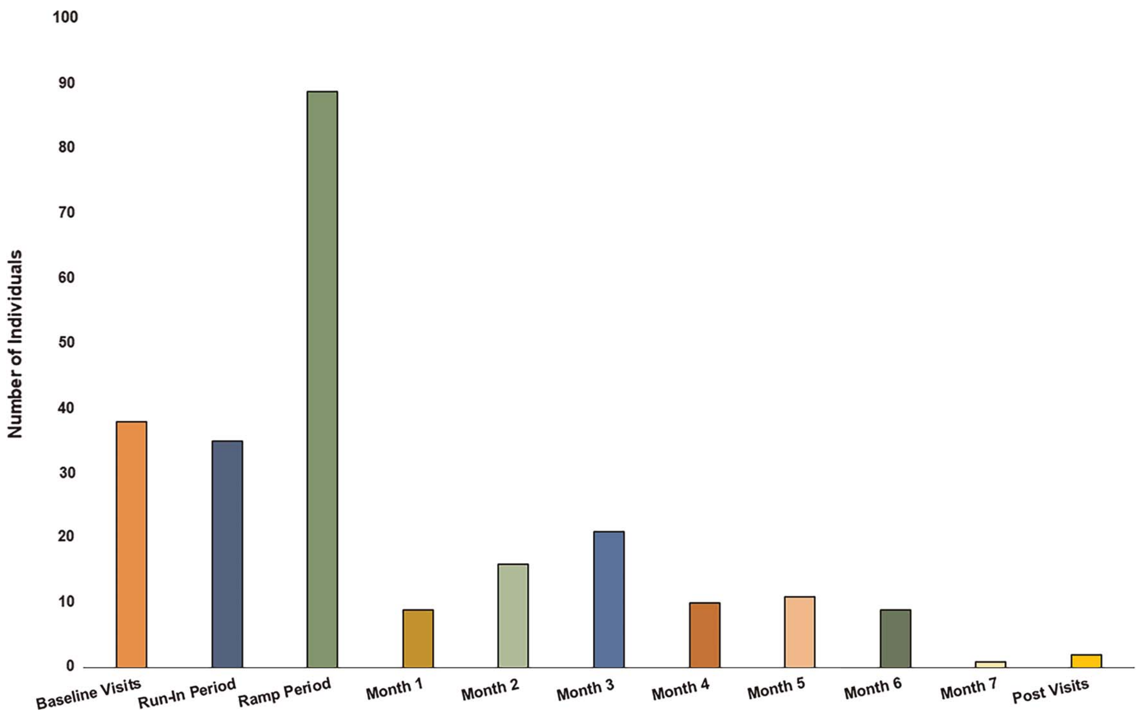

Figure 2: Incidence of exercise intervention dropout across all three STRRIDE studies.

Adherence Findings

For the exercise intervention completers across all three STRRIDE trials, percent adherence remained relatively constant (Fig. 4) after the ramp period, with some variation toward the latter weeks of the exercise intervention. Total mean percent adherence values for the exercise intervention for each STRRIDE trial were as follows: 87.5% ± 13.6% for STRRIDE I, 82.2% ± 17.1% for STRRIDE AT/RT, and 85.1% ± 16.2% for STRRIDE-PD.

DISCUSSION

The purpose of this secondary analysis was to characterize the timing of dropout from structured exercise interventions, stated reasons for dropout, and the associations between

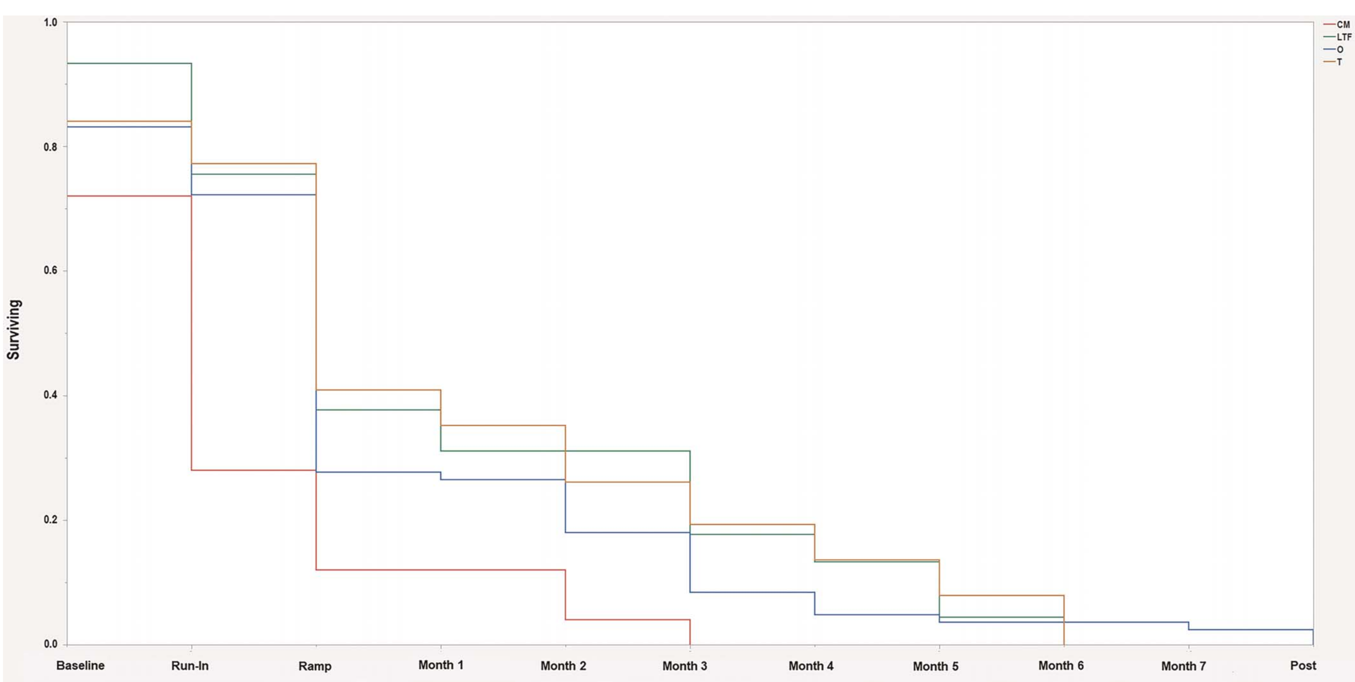

Figure 3: Survival curve analysis of timing of exercise intervention dropout by determinant categories. CM, changed mind; LTF, lost to follow-up; O, other; T, time.

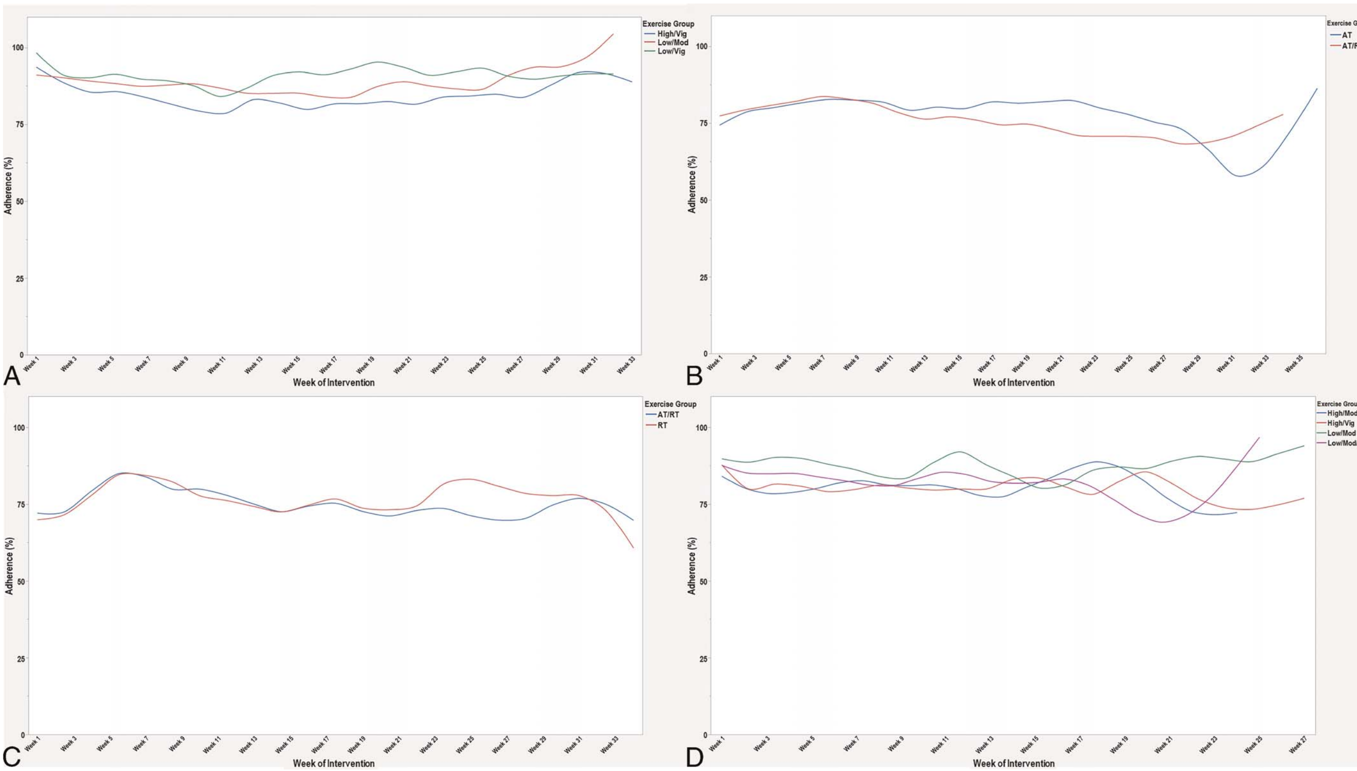

Figure 4: A, STRRIDE I mean percent adherence by exercise intervention group, excluding the control group. High/Vig, high amount/vigorous intensity; Low/Mod, low amount/moderate intensity; Low/Vig, low amount/vigorous intensity. B, STRRIDE AT/RT mean percent adherence to the aerobic prescription by exercise intervention group. AT, aerobic training; AT/RT, aerobic + resistance training. C, STRRIDE AT/RT mean percent adherence to the resistance prescription by exercise intervention group. RT, resistance training; AT/RT, aerobic + resistance training. D, STRRIDE-PD mean percent adherence by exercise intervention group. High/Mod, high-amount/moderate-intensity aerobic exercise; High/Vig, high-amount/vigorous-intensity aerobic exercise; Low/Mod, low-amount/moderate-intensity aerobic exercise; Low/Mod/Diet, low-amount/moderate-intensity aerobic exercise + diet.

the two among sedentary adults with overweight or obesity. We also examined variation in mean percent adherence to prescribed exercise over 6- to 8-month interventions.

Comparing baseline demographic characteristics between participants who completed one of the STRRIDE interventions versus those who dropped out, we found key differences in race, body mass index, and cardiorespiratory fitness ($\dot{V}O_{2peak}$). Individuals who dropped out were typically less fit and had a higher body mass index, which may be clinically relevant for why these participants dropped out. Further research is needed to assess race as a key determinant of dropout.

When exploring determinants of exercise intervention dropout, we found the most prevalent reason individuals reported for dropping out was lack of time, or a combination of lack of time due to family and/or work, and motivation (Fig. 1). In a systematic review assessing determinants of adherence to lifestyle interventions among adults with obesity (11), the authors concluded the most prominent barriers of behavior change include poor motivation (14–19); lack of time (14–18); environmental, societal, and social pressures (14,17–19); health and physical limitations (14,17,18,20); negative thoughts/moods (14–16); socioeconomic constraints (14,19); gaps in knowledge/lack of awareness (16,18); and lack of enjoyment of exercise (17). Although our findings for dropout determinants are similar, we did not assess potentially influential behavioral constructs—such as conscientiousness, self-efficacy, and social support—on dropout determinants. Therefore, future research should continue to assess behavioral constructs to provide greater understanding for why individuals decide to dropout of exercise interventions.

Furthermore, when examining time to dropout across our structured exercise interventions, about two-thirds (66%) of individuals who dropped out did so before the start of the exercise intervention at its prescribed intensity. Predominantly, dropout occurred during the ramp period (Fig. 2) in which individuals had begun exercise but were not at the level needed to fulfill their prescriptions. The dropout variability observed in the STRRIDE studies may have been due to 1) differences in study design, such as including a run-in period in STRRIDE AT/RT; 2) variation in length of the ramp-up periods across each STRRIDE; and 3) although there was a ramp period, the higher amount and intensity exercise training groups may have been too lofty for sedentary individuals with overweight or obesity. Per the literature, average exercise intervention dropout is about 20% (2–4), with 50% of dropouts occurring in the first 6 months of exercise onset (8,9,12,21). In a 6-month study assessing older adults taking part in organized exercise programs within the community, 15% of participants dropped out during the first 6 months of exercise participation onset (12). The authors' rationale for this relatively low dropout percentage is because the intervention included organized exercise programs, for which older adults have greater adherence (12). Because there is little literature discussing determinants and timing of structured exercise intervention dropout, future research should place emphasis on defining dropout separate from adherence to properly identify the period in which individuals are at the greatest risk for dropout.

Moreover, when analyzing the association between dropout determinants and timing of dropout, we found that of those participants who dropped out because they changed their minds, the majority did so during the run-in period, before starting any exercise. For the remainder of dropout determinant categories, participants primarily dropped out during the intervention ramp period (Fig. 3), before achieving the prescribed exercise amount and intensity. These findings provide insight into the variability of behavior change that leads to variation in timing of exercise intervention dropout. Although exercise researchers may not consider the run-in or ramp periods as having started the intervention, the participants likely had a different perspective. Further research is needed to clarify the components of changing one's mind and the participant experience. Motivational factors, competing commitments, and physical discomfort may all contribute; each would benefit from a distinct type of intervention. For example, motivational interviewing and health coaching might be useful for motivational factors (22–24), health coaching using a competing commitments model might assist in the second case (25,26), and amending intervention details in the exercise run-in or ramp periods might assist in the third case. Although few studies have examined stage-specific associations with dropout, it is possible that the ramp period of training was experienced by some participants as more physiologically burdensome and time intensive, which could have reduced their self-efficacy and confidence in their ability to maintain adherence over time. Participants may also hold inaccurate perceptions—such as a belief that they are already active enough—that require an effective educational intervention (27). Future research should further explore the behavioral constructs and mechanisms behind when and why individuals decide to dropout from an exercise intervention.

Lastly, we assessed if there was variation across the STRRIDE clinical trials among intervention completers in mean percent adherence of exercise participation across time. Mean percent adherence seemed to remain constant across all three STRRIDE trials. However, there was some drift toward the end of each STRRIDE intervention, which may be due to the smaller sample of individuals represented during the later weeks for makeup exercise sessions as well as the variation in study designs. These findings underscore that once an individual adopts and adheres to an exercise intervention, they will typically maintain consistent participation in exercise over the course of the intervention. However, because the STRRIDE trials were only 6 to 8 months in duration, future research should investigate the consistence of percent adherence to exercise over a longer duration of time.

This study provides implications for researchers designing exercise interventions aiming to reduce dropout. First, the STRRIDE trials indicate most individuals will dropout before or within 2 to 3 months of exercise training onset. Thus, investigators should place greater targeting efforts on this adoption period to promote exercise intervention adherence. Our findings are consistent with prior work examining stage-specific intervention approaches, in which increases in self-efficacy over the first several months of training are important determinants of subsequent treatment maintenance (28). Second, the majority of individuals dropped out during the ramp phase of the exercise intervention, suggesting the way current interventions ramp up to exercise prescriptions may be too lofty for sedentary individuals with overweight or obesity. Thus, investigators should consider adjusting this phase of the exercise intervention to compensate for individuals who struggle incorporating exercise into their daily routine. Third, the majority of individuals who changed their mind did so during the run-in phase of the exercise intervention. Hence, when designing an exercise intervention, avoiding a long run-in period and starting the exercise portion immediately may prevent individuals from changing their minds. Further exploration of participant perceptions during the run-in and ramp phases would assist with intervention design. Fourth, this study shows that once individuals make it past the initial 2- to 3-month ramp period (i.e., adoption period), they typically are consistent in adhering to a 6- to 8-month exercise intervention. Further efforts focused on run-in and ramp periods can leverage this new evidence that once an individual adopts the exercise behavior, they will adhere to the intervention for at least 6 to 8 months.

This study does not come without limitations. The STRRIDE exercise interventions were performed under supervised exercise conditions and may not reflect all real-world situations surrounding exercise intervention dropout. All three STRRIDE trials were different in study design, exercise intervention length, and inclusion of run-in or ramp periods. Lastly, this study is limited in its ability to explore factors other than behavioral and environmental, which lead to dropout or adherence to exercise interventions. Thus, exploring additional factors—such as genetic and molecular determinants—that may predispose an individual's decision making and behavior change process is important to investigate to generate a complete map of the behavior change process within the context of an exercise intervention.

CONCLUSIONS

This study is one of the first to investigate the association between dropout determinants and timing. We found the most common reason for exercise intervention dropout was lack of time, and individuals who dropped out primarily did so during the ramp period of the exercise interventions. Furthermore, as compared with other dropout determinant categories, individuals changing their mind about participating dropped out earlier, before exercise initiation. In addition, among intervention completers, exercise intervention adherence was consistent over 6 to 8 months. The overall implications of this analysis show dropout occurs early on, most likely before the start of month 1 of the exercise intervention. These findings provide guidance to future exercise interventions targeting individuals at risk for dropout.

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