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Exposing College Students to Exercise: The Training Interventions and Genetics of Exercise Response (TIGER) Study

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Abstract

Objective—The Training Interventions and Genetics of Exercise Response (TIGER) Study is an exercise program designed to introduce sedentary college students to regular physical activity and to identify genetic factors that influence response to exercise.

Participants—A multi-racial/ethnic cohort (N=1,567; 39% male), age 18–35y, participated in the study.

Methods—Subjects underwent 30-weeks of exercise training, 3-days/week, for 40-min at 65–85% of age- and gender-predicted maximum heart rate reserve. Multiple measures of body size/composition, heart rate, and blood pressure were obtained.

Results—A total of 1,567 participants, (39% male), age 18–35 y, participated in the TIGER Study. The prevalence of overweight/obesity in participants was 48.0%/19.3% in non-Hispanic Whites, 55.3%/ 24.2% in Hispanic Whites, 54.9%/25.4% in African Americans, and 38.3%/11.3% in Asians. Average within-semester retention was 68%, but overall retention (30 weeks, two semesters) was 20%.

Conclusions—The TIGER Study represents an efficacious strategy for introducing college-aged individuals to regular aerobic exercise.

BACKGROUND

Among today's major public health concerns is the rapid rise in obesity, which approaches 30%, even among young adults (20–39 y)[1]. The increasing prevalence of obesity among young people is combined with a concomitant low rate of physical activity, with nearly 43% of college undergraduates reporting they do not participate in either moderate or vigorous physical activity[2]. An exercise program presented at the transition from home to university

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life may be a critical mechanism to deter the expected progression from overweight adolescent to obese adult and intervene on a young person at a crucial time when he/she is beginning to feel empowered by independence. This is a major component of the Training Interventions and Genetics of Exercise Response (TIGER) Study.

The TIGER Study began in 2003 with the initial goal of identifying genetic factors that influence response to exercise training, while introducing sedentary college-age individuals to regular exercise via a 3-day/week course taken for college credit. Other successful studies of young adults undergoing moderate intensity aerobic exercise interventions provide support for an exercise-based approach to fitness and weight management [3, 4]. Surprisingly, few exercise intervention studies have targeted this age group and none have provided an exercise intervention in the form of a course for college credit. Since time is often given as a limiting factor in exercise adherence, we designed a study in which exercise would be included as part of the normal college routine. The TIGER study is designed to investigate the cross-sectional and longitudinal roles of genes related to adiposity and metabolism on levels of body fatness, blood pressure and blood components both prior to and following a 30-week exercise intervention program in a diverse population of college-age individuals.

METHODS

Study Design and Sampling

The TIGER Study utilizes a longitudinal study design in which self-selected subjects measured three times during the course of the study serve as their own statistical controls in longitudinal modeling of the repeated measures data. The statistical design involves both cross-sectional analysis of the baseline data and longitudinal modeling of the repeated measures data. The design and methods of the TIGER study are guided in large part by social cognitive theory, complimented by self-determination theory, self-schema theory, and the transtheoretical model of stages of change [5–9]. Concepts of self-efficacy, motivation, social context, self-identity, and the development of intrinsic and extrinsic motives for physical activity and exercise are central to the design of the TIGER study. We hypothesize that the implementation of an exercise program during young adulthood will be able to evoke improvements in physiological characteristics among young adults and will result in increased self-efficacy and learned skills that can be used throughout life. This paper presents a description of the TIGER Study protocol, along with results for physical measures at baseline.

The target subject for the study was a sedentary individual who has exercised less than 30-min/week for the previous 30 days, and who was not actively limiting caloric intake. In the five-year course of the study, a total of 1,567 University of Houston students, age 18–35 y, enrolled in the TIGER study. Subjects were excluded from the study if they had a physical contra-indication to exercise, as identified by their physician; a known metabolic disorder that may alter body composition; were pregnant or lactating; or were already actively participating in a regular exercise program within the previous 30 days. Subjects were not selected by obesity status to ensure that a wide variety of body types were represented.

Participants were actively recruited through advertisements in the local and UH campus newspapers, flyers placed in each UH campus building, and through personal contact with student groups such as fraternities/sororities and student organizations. Recruitment was augmented with the presentation five-minute ‘mini talks’ in large lecture classes. The mini talks were designed to inform prospective students about the study and to encourage them to consider enrollment. Presentations were also made at freshman orientation seminars and other student functions. These efforts resulted in an efficient mechanism for recruiting student participants into the study.

The TIGER study represented a collaboration between investigators at Baylor College of Medicine, the University of Houston, and the University of Texas Health Science Center at Houston and was approved by the respective Institutional Review Boards of each institution. Prior to participation in any study-related activities, all prospective subjects provided written informed consent.

Measurement Protocol

The protocol included three physical examinations during the course of the study (baseline, 15-weeks and 30-weeks). At each examination, subjects completed questionnaires designed to assess basic demographics, medical/family history, smoking/alcohol intake history, weight history, medication use, eating behavior, dietary intake, sleep habits, psychosocial factors, habitual physical activity, menstrual history, and hormone use.

Body weight was measured using a digital scale (Seca 770, Hanover, MD), and height was assessed with a portable stadiometer (Seca Road Rod). Waist and hip circumferences were measured manually using a Gulick tension-calibrated tape measure (Creative Health Products, Ann Arbor, MI). The waist measurement was taken as a horizontal circumference at the umbilicus while the hip measurement was taken at the largest horizontal circumference around the buttocks. Skinfolds were measured using Lange (Beta Technology, Inc., Santa Cruz, CA) or Lafayette (Lafayette Instruments, Inc., Lafayette, LA) skinfold calipers following standard protocols. Skinfold measures for males were taken at the chest, abdomen, and thigh, and female skinfold measures were taken at the triceps, iliac crest, and thigh[10, 11]. The average of three measures for each of the anthropometric components was used for analysis.

Resting heart rate and blood pressure were measured using digital blood pressure monitors (Omron HEM-907XL, Bannockburn, Illinois). Blood pressure and resting heart rate were measured three times at each examination, and the average of the last two measures was used for analysis. Lean mass, fat mass, and bone mineral content was determined from dual energy x-ray absorptiometry (DXA) (Hologic Delphia-A unit adult whole body software v. 11.2 and Hologic Discovery W instrument adult whole body software QDR v.12.3). A small blood sample (10 mL, EDTA treated) was collected by venipuncture at each examination for the extraction of DNA and measurement of blood analytes. All staff completed a comprehensive training module prior to measuring any subject and trained nurses and radiation technologists performed the venipuncture and DXA examinations.

Exercise Protocol

The exercise protocol consisted of a 30-week (Fall and Spring semesters), 3-day/week exercise training program offered as part of the University of Houston curriculum. Each exercise session lasted a minimum of 40 minutes and consisted of a 5-minute warm-up, 30-minute workout, and a 5-minute cool-down. Subjects exercised using computerized heart rate monitors (Polar E600, Irvine, CA) with audible feedback, with the target heart rate zone (THRZ) set between 65–85% of each person's age- and gender-specific predicted maximum heart rate reserve. To be considered a valid workout, the subject was required to complete at least 25 minutes within his/her THRZ for each exercise session. Heart rate monitors were downloaded via infrared readers directly to a database in order to document the intensity and duration of every exercise session. Subjects performed their choice of aerobic exercise modes which included stationary cycling, treadmill or track running/walking, elliptical stepping, rowing, stair stepping, and arm ergometry. Study staff members documented exercise mode for each session by direct observation and recorded this data using a handheld computer.

In addition to the in-class exercise sessions, the TIGER Study partnered with CSI Software, Inc. (http://www.csisoftwareusa.com) to provide an online activity logging program through which the study subjects documented exercise performed outside of class. The CSI program included an exercise log that allowed the staff to track individual patterns of exercise from both within and outside of the study class times for each subject for any selected period.

Subject Education and Feedback

The TIGER study protocol also included an educational component, and students received college credit for each semester in which they were enrolled. The educational component provided learning experiences in fitness and physiology relevant to public health. Lecture topics included cardiovascular health, body composition, nutrition, genetics, energy balance, exercise program design, stretching, and exercise tracking. Additionally, the online activity monitoring program available to all subjects supplied immediate feedback in estimated caloric expenditure as well as daily and weekly activity level. Subjects also received summary reports after each physical examination that included results of all exams, along with a norms page to aid in the interpretation of the results. Graphic reports that summarized heart rate intensity during the workout sessions were also generated regularly as positive feedback for the participants to encourage students to continue to put full effort into maintaining exercise intensity throughout their workouts. To facilitate communication between study research staff and the participants, and to aid in subject recruitment, a website was developed for the study (http://www.uh.edu/tigerstudy) that included information about the study, links to the exercise logging program used in the study, a weekly updated tally of workouts for each subject, and other useful sites.

Data Entry and Data Management

An electronic data entry system (Teleform, Cardiff, Inc., San Diego, CA) was used to create specialized, scannable forms, in order to automate data entry and minimize errors. Data from each form were entered into the database automatically with a scanner, and every data field on each form was verified independently by two TIGER Study staff members. Any discrepancies in the data were resolved before the data was transferred to the central database archive computer at BCM.

Statistical Analysis

Mean and standard deviations were calculated for all physiologic measures by gender and race/ethnicity and analysis of variance was performed to determine if there were significant differences among race/ethnicity groups for all baseline physiologic measures. Chi-square, logistic regression and analysis of variance were performed to determine if retention rates were significantly different by gender, race/ethnicity and all continuous phenotypes. STATA software (version 10; StataCorp LP, College Station, TX, USA) was used for all statistical analyses and a p-value of 0.05 was used to determine significance.

RESULTS

The racial/ethnic distribution of TIGER Study participants was 29.1% non-Hispanic white (NHW), 22.9% Hispanic (HISP), 28.1% African American (AA), 7.5% Asian, 3.9% Asian Indian, 0.2% Native American, and 8.4% other. The subjects in the study were generally healthy but had rates of overweight and obesity similar to national norms[1] (Figure 1). Baseline means and standard deviations by gender and race/ethnicity for all body size measures, blood pressure, and heart rate are provided in Table 1. There were significant racial/ethnic differences at baseline in age, waist hip ratio, percent body fat, bone mineral density, diastolic blood pressure and heart rate in males, while females had significant race/

ethnicity differences at baseline in weight, BMI, waist and hip circumferences, waist/hip ratio, percent body fat, BMD, and systolic blood pressure.

Subjects in the TIGER Study were instructed to exercise between 65% and 85% of their age- and gender-predicted maximum heart rate reserve for 30 minutes three days per week. The most frequent mode of exercise chosen was the elliptical trainer (48.4% of sessions), followed by running on the indoor track (29.4% of sessions) and treadmill (15.9% of sessions). The remaining 6.3% of exercise sessions consisted of students using the exercise cycles, stair-climbers, arm ergometers, participating in group exercise, or doing multiple activities (i.e. doing two or more of the above activities during an exercise session). A total of 42,279 exercise sessions were recorded on heart rate monitors over the course of the entire study. Approximately 84% of exercise sessions were conducted at the prescribed intensity and duration, with an average time in the target heart rate zone of 30.1 min (SD=6.0 min) and an average relative exercise intensity of 70.3% HRR (SD=8.4%). A total of 3.1% of the sessions recorded were not usable for analysis due to recording errors. The remaining 12.9% of sessions were those sessions that were considered non-compliant with the exercise protocol. These sessions had an average time in the target heart rate zone of 18.9 min (SD=9.9 min) and an average exercise intensity of 54.2% HRR (SD=6.0%).

Exercise dropouts were defined as those individuals who completed less than 80% of the exercise sessions for a given semester. Average within-semester retention was 68% (average Fall semester retention = 62%; average Spring semester retention = 74%) but average retention across semesters was approximately 20%. Retention rates for both Fall and Spring semesters increased as the study progressed (Figure 2). As shown in Table 2, there were no significant differences in attrition rates between males (40%) and females (37%) ($p=0.161$) or between the racial/ethnic groups ($p=0.101$). Individuals who adhered to the TIGER protocol for the first 15-weeks were significantly younger, weighed less, were shorter, had a smaller waist and hip circumferences, and a lower waist/hip ratio and BMI. Importantly, those who adhered to the study protocol exercised at a significantly ($p<0.001$) higher average intensity and spent significantly more time in the THRZ ($p<0.001$) compared to those who dropped out of the study (Table 2).

COMMENTS

Limitations

Subjects in the study represent self-selected individuals rather than a random sample. Second, the study involves 30-weeks of exercise training, and provides limited information as to the long term effects of the intervention. Future plans for the study include ascertainment of a larger subject sample, more extensive assessment of lifestyle changes that occur consequent to initiating the exercise program, and long-term follow-up of subjects to determine whether changes in physical activity behavior persist once the intervention is removed.

Conclusions

The TIGER Study was designed to expose young adults to regular exercise under the supervision of trained instructors within a college course setting and, ultimately, to determine genetic factors that influence response to exercise. This study was the first to document the intensity and duration of every exercise session with computerized heart rate monitors, providing the capability to quantitatively assess exercise adherence and dose. The majority of TIGER participants complied with the exercise protocol, completing at least 25 THRZ minutes for 80% or more of the prescribed exercise sessions. Even for those sessions where participants were not compliant, moderate exercise intensity (average intensity 54.2

±6.0% heart rate reserve) was attained. Several investigators report that subjects typically exercise at moderate intensity even when not instructed to do so but understand and are able to achieve higher heart rates during exercise[12–18]. For example, middle-aged male and female recreational walkers exercised at a self-preferred intensity of 59.0% (± 13.4%) VO_2 max but when asked to walk "briskly", they significantly increased their mean exercise intensities to an average of 68.6% (±14.9%) VO_2 max [16]. Based on our data, as well as previous reports, the TIGER Study protocol consisted of an exercise intensity that would be considered both appropriate and achievable for young adults. Based on our data, higher exercise intensity was associated with higher exercise adherence.

Standards for determining the level of exercise adherence vary greatly (50%–100% completion of exercise sessions) and no consensus for defining adherence currently exists[19–21]. TIGER study participants were required to complete a minimum of 80% of prescribed workouts in order to be considered compliant and to meet college credit requirements. Greater than 86% of subjects in the TIGER study completed 50% or more of the prescribed workouts. Despite using rigorous standards to define adherence, subject retention in the TIGER Study was similar to that reported in other studies[4, 22–28]. Several students dropped within the first week, which for most was due to scheduling conflicts. After excluding individuals who dropped within the first week, we observed an average adherence rate of 69% for the Fall semester and an adherence rate of 74% for those who enrolled in the Spring semester. These within-semester adherence rates are higher than similar studies reporting adherence rates of 40–50% after 6 months of exercise[25–27]. Donnelly (2003) reported an overall adherence rate of 47% in a 16-month exercise study in which participants were compensated to remain in the program[4].

The TIGER study participants did not receive any form of compensation, other than college credit, for which they paid college tuition. Therefore the structure of a formal class for credit appeared to be a motivating factor in maintaining adherence to the study protocol. The TIGER study involved a two-semester college course for credit and there was substantial dropout at the 15-week time point with an overall adherence rate of 20% for 30 weeks. Individuals who did not complete both semesters of the study most often attributed their dropout to difficulties in scheduling or financial burden. Whether the TIGER participants continue to maintain their physical activity levels following withdrawal from the study has not yet been formally evaluated; nevertheless, 61% of subjects responding to an informal exit questionnaire administered approximately four-weeks following withdrawal from the study indicated they were still exercising regularly 3-days/week.

There was a substantial contingent of TIGER participants who persisted in exercise, even while articulating barriers such as finances, time, and other obligations. Participation in the TIGER Study may have enhanced feelings of self-efficacy, since a non-judgmental approach was used in the study to teach students how to exercise within a suitable prescribed target heart rate zone intended to produce positive physical changes. Participating in the TIGER Study also included social contexts of group membership and positive reinforcement in the form of personal contact with the research staff and feedback in the form of graphical displays in workout summaries and reports of physical exam results. All of these factors combined can be utilized in college campuses to afford students the opportunity to incorporate physical activity and healthy behaviors at a critical phase in young adulthood.

For most participants, the TIGER study was their first exposure in learning how to achieve a training heart rate that was designed to elicit physiologic change. As the subjects experienced the prescribed exercise intensities over the course of many weeks, they acquired the ability to achieve these intensities routinely without the constant feedback of a heart rate monitor, as demonstrated by self reported exercise intensities for physical activity outside of

class. Thus, teaching subjects how to achieve and maintain a heart rate associated with cardiovascular fitness and energy balance ultimately provided a lifelong skill that can be used to control body weight. Those individuals who adhered to the protocol had significantly higher average exercise intensity and time spent in the THRZ during each exercise session as compare to those who dropped from the study, suggesting that individuals may more readily adhere to an exercise protocol of higher intensity because they see greater immediate improvements in body size and other physical attributes.

Recently, Neovius et al. (2009) reported that obesity and overweight in young adulthood increased adult mortality independently and equivalently to heavy and light smoking, respectively, thus emphasizing the importance of obesity prevention in early adulthood[29]. Physical activity can directly prevent or attenuate obesity in almost all individuals, without the side effects that are caused by pharmacologic or surgical interventions. The largest declines in physical activity are typically seen in adolescents and young adults[30]; thus, the transition from high school to college is a critical time to introduce exercise to both obese and non-obese individuals. The course-based approach used in the TIGER study follows the widely-quoted recommendation to “make the healthy choice the easy or default choice.” The TIGER study represents an efficacious strategy for introducing regular physical activity that can potentially impact future obesity risk.

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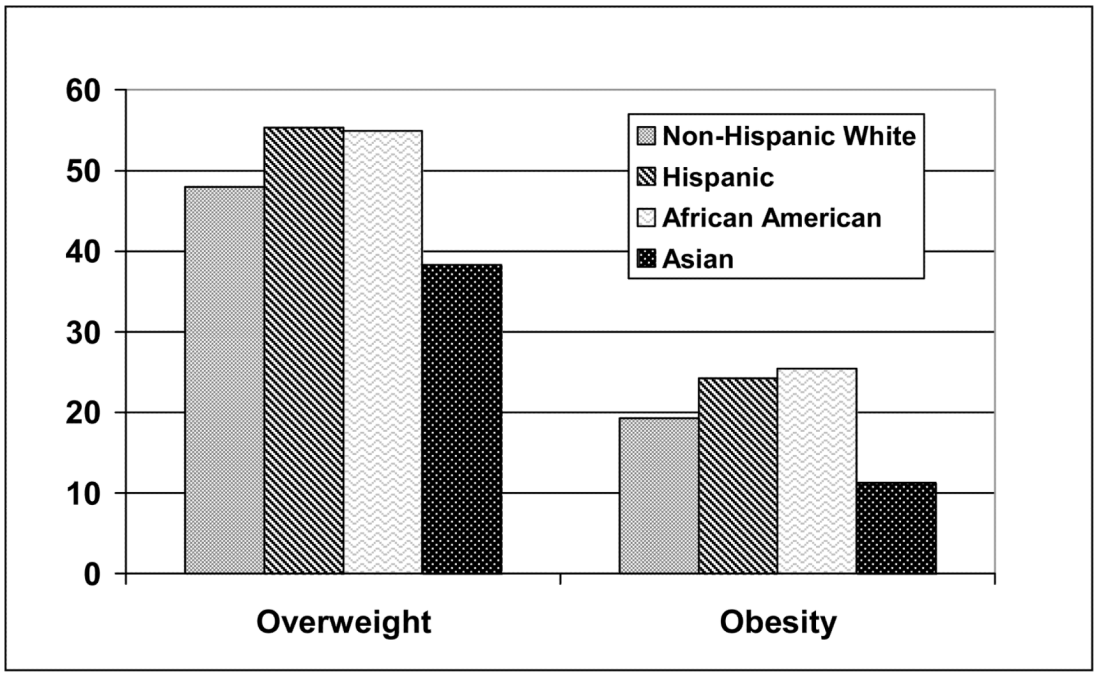

Figure 1.
Prevalence of Overweight and Obesity in the TIGER Study by Racial / Ethnic Groups

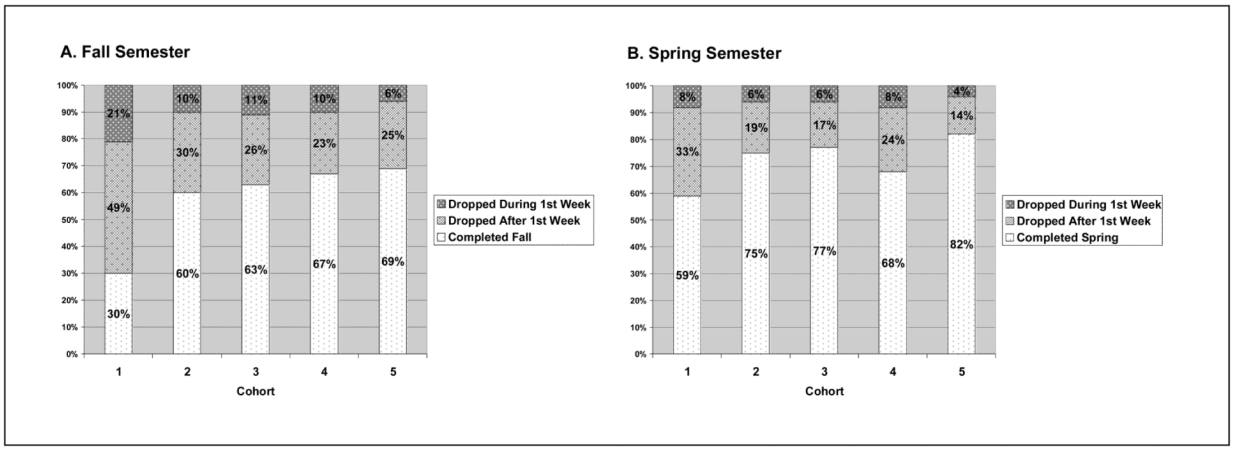

Figure 2.

Figure 2a and 2b. Retention Rates for the Fall and Spring Semester by Cohort.
Columns represent one cohort. Columns are partitioned into three parts representing the percentage of participants in that cohort who completed the semester, dropped after the first week of the semester, or dropped during the first week of the semester.

Table 1

Means and standard deviations for baseline body size, blood pressure and heart rate

	Males								Females							
	White (n=197)		Hispanic (n=139)		African- American (n=119)		Asian (n=49)		White (n=249)		Hispanic (n=209)		African- American (n=302)		Asian (n=66)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Age (y)*	22.3	3.5	21.7	2.8	21.0	2.8	21.6	2.7	21.2	2.9	21.4	3.2	21.2	3.6	21.0	2.5
Weight (kg)^	85.7	19.2	83.5	20.1	88.1	23.6	80.3	22.5	68.7	16.7	67.0	15.5	73.7	21.4	55.3	12.1
BMI (kg/m^2)^	27.2	5.5	27.9	5.9	27.9	6.7	27.1	6.4	25.4	5.9	26.4	5.8	27.4	7.3	22.3	4.1
Waist Circ (cm)^	89.6	14.5	90.3	15.4	85.6	17.3	87.7	22.5	76.6	12.9	78.4	11.6	79.4	15.6	69.5	9.4
Hip Circ (cm)^	103.9	11.1	102.5	11.6	103.3	13.6	101.7	18.6	102.1	11.4	102.2	11.9	104.9	15.0	92.3	9.1
WHR*^	0.86	0.06	0.88	0.07	0.82	0.06	0.85	0.07	0.75	0.06	0.77	0.05	0.75	0.07	0.75	0.05
Skinfold BF%*^	20.1	9.0	20.1	8.7	15.8	10.3	19.8	9.7	28.7	6.8	29.7	6.7	29.6	8.4	26.6	6.3
DXA BF%*^	21.3	7.7	21.9	7.3	16.8	8.4	21.5	8.1	31.3	7.4	34.3	6.6	31.5	8.0	30.8	5.8
DXA BMD*^	1.22	0.11	1.22	0.12	1.32	0.12	1.21	0.08	1.13	0.09	1.11	0.09	1.19	0.10	1.10	0.08
Systolic BP^	124	12	124	12	122	10	121	11	110	10	109	10	111	12	105	11
Diastolic BP*	68	10	67	10	65	10	71	9	67	8	66	9	68	10	65	9
Heart Rate (bpm)*	72	13	70	12	67	10	78	13	76	12	76	11	77	11	77	10

* $p<0.05$ in Males;

^ $p<0.05$ in females

WHR: waist hip ratio; BF%: body fat percent; DXA: dual energy x-ray absorptiometry; BMD: bone mineral density; BP: blood pressure; bpm: beats per minute

Table 2

Characteristics of TIGER Participants who Adhere or Drop within the first 15-weeks

	Adherers n (%)	Drop Outs n (%)	*p*
Gender			0.161
Males	362 (60%)	608 (40%)	
Females	608 (63%)	353 (37%)	
Race			0.101
Non-Hispanic Whites	259 (58%)	191 (42%)	
Hispanics	235 (66%)	119 (34%)	
African American	260 (60%)	175 (40%)	
Native American	1 (33%)	2 (67%)	
Asian Indian	40 (67%)	20 (33%)	
Asian	75 (65%)	41 (35%)	
	M ± SD	**M ± SD**	***p***
Age	21.3 ± 2.9	21.7 ± 3.5	**0.008**
Weight (kg)	72.9 ± 19.9	76.7 ± 21.9	**0.001**
Height (cm)	166.7 ± 9.5	167.8 ± 9.7	**0.040**
Waist (cm)	80.0 ± 15.0	83.9 ± 16.6	**<0.001**
Hip (cm)	101.3 ± 12.4	103.9 ± 13.3	**<0.001**
WHR	0.79 ± 0.08	0.80 ± 0.08	**<0.001**
BMI	26.1 ± 5.9	27.1 ± 6.6	**0.002**
DXA % Fat	27.5 ± 9.3	28.1 ± 9.9	0.245
Exercise Intensity (%HRR)	67.9 ± 6.0	65.9 ± 7.0	**<0.001**
Minutes in THRZ (min)	27.2 ± 5.8	24.3 ± 8.0	**<0.001**

WHR: waist hip ratio; DXA: dual energy x-ray absorptiometry; HRR: heart rate reserve; THRZ: target heart rate zone