ABSTRACT

Title of Document: THE EFFECTS OF STRENGTH TRAINING ON REGIONAL BODY COMPOSITION IN OLDER ADULTS: SEX AND RACE COMPARISONS

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Purpose: To examine the influence of sex and race on the effects of strength training (ST) on thigh muscle volume (MV), mid-thigh subcutaneous fat (SCF) and intermuscular fat (IMF). **Methods:** One hundred and eighty-one previously inactive healthy Caucasian (N=117), African-American (N=54), and other (N=10) men (N=82) and women (N=99), aged 50-85 yrs, underwent ~10 weeks of unilateral knee extension ST. **Results:** Training-induced increases in absolute MV were significantly greater ($P < 0.01$) in men than in women. There were significant increases in MV within each race ($P < 0.001$); but no significant differences between races. There were no significant changes in SCF and IMF whether sex and racial groups were separated or combined. In addition, there was no sex by race interaction for changes in MV, SCF, or IMF with ST. **Conclusion:** Ten weeks of unilateral strength training does not alter subcutaneous or intermuscular fat regardless of sex or racial differences. Although men exhibit a greater muscle hypertrophic response to strength training compared to women, the difference is small. Race does not influence this response.

EFFECTS OF STRENGTH TRAINING ON REGIONAL BODY COMPOSITION IN OLDER ADULTS: SEX AND RACE COMPARISONS

By

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INTRODUCTION

The loss of muscle mass with age (sarcopenia) is associated with a decline in strength (70; 79) and functional abilities (144). This loss of strength in the aging population is an independent predictor of both functional limitations (102) and mortality (66; 79; 89). Additionally, strength per unit of muscle (muscle quality) decreases during the life span (73; 78) and is linked with risk of mortality (79). Sarcopenia is associated with a rise in total body fat, as well as an increase in the amount of fat that infiltrates skeletal muscle (37). Muscle fat infiltration is associated with diabetes (39) and is a predictor of mobility loss in older men and women (144). Thus, delaying the onset of sarcopenia and its related consequences has important health implications for older adults.

The age-associated changes in regional body composition, and its comorbidities, may be influenced by sex and race differences. Women at risk for sarcopenia have demonstrated poorer performance in functional tasks than men (77). One possible explanation for this is that older women have more low density muscle, indicating greater lipid infiltration (37). In addition, women contain a higher SCF area and inferior strength in the lower limb than men (89). Men have also been shown to possess lower percent body fat and greater arm and leg muscle mass than women throughout the entire adult life span (73).

Older African-Americans (AA) have reported a higher frequency of functional limitations and disability than Caucasians (93). While AA exhibit greater limb muscle mass than Caucasians of similar height, body mass, age, and sex (31), older AA have greater absolute areas of thigh SCF and IMF than their Caucasian counterparts (37).

Moreover, AA postmenopausal women have greater SCF and abdominal fat and estimated mid-thigh intramuscular fat than Caucasian women of similar age and total body fat percentage (114). These studies suggest that elevated fat content within and around the muscle, could at least partially explain why muscle quality (88) and functional ability (93) tend to be lower in older AA than Caucasians. Variation in regional body composition appears to be related to sex and race differences in age-associated dysfunction and disability.

ST has become the intervention of choice for the prevention and treatment of sarcopenia and its related consequences (49; 109). This mode of exercise increases limb MV, strength, and muscle quality (MQ) in older adults (136). Greater muscle strength along with more frequent physical exercise is associated with less severe disability in both AA and Caucasian women (103). However, due to the lack of information available on the effectiveness of ST for reducing limb fat (64; 140), ST has not been advocated for improving regional body composition for any subpopulation.

The few published studies on this topic have provided conflicting results. For example, Ross et al. (107; 108) concluded that ST is as effective as aerobic training for reducing abdominal and gluteal/femoral region fat stores in men and women after observing similar reductions in SCF between the two training modalities when combined with a diet. Treuth et al. (140) also observed significant reductions in regional (arms, legs, and trunk) and total body fat mass in previously sedentary older men following full body ST. In a separate study, Treuth et al. (138) reported a significant decline in intra-abdominal fat after full body ST in postmenopausal

women. Similar findings were demonstrated by Hunter et al. (48) in older women, however older men did not experience a reduction in abdominal SCF with full body ST. In contrast to the findings of Ross et al. (107; 108), Treuth et al. (138; 140), and Hunter et al. (48), Binder et al. (9) found no significant changes in trunk, intra-abdominal, or SCF mass with full body ST in either sex. Sipila et al. (122) reported a reduced percentage of thigh IMF in response to a combined full body ST and endurance training program in older women, but provided no information on absolute IMF change. The reduced percentage of fat may have been due to the increase in thigh muscle mass alone, which would lower the percentage of fat tissue, even in the absence of changes in total fat mass. Preliminary data from our lab shows that change in IMF with single-leg ST was influenced by the adrenergic receptor genotype (150). Sex and race comparisons were not made in that study, nor was SCF analyzed. There are conflicting results on the influence of sex on muscle size response to ST (50; 110; 136), and the racial influence is unknown. These inconsistent results may be due to methodological differences between studies and the absence of appropriate controls for factors other than ST that may alter regional body composition.

To date, no reports could be found on the sex and racial influences on the independent consequences of ST on lower limb MV, SCF, and IMF in older adults. Therefore, the purpose of this study was to examine the effects of ST on thigh MV, mid-thigh SCF, and mid-thigh IMF, and determine the influence of sex and race differences on these effects in healthy middle-aged and older adults.

METHODS

Subjects

One-hundred and eighty-one relatively healthy, sedentary volunteers [82 men (63 ± 0.9 yr), 99 women (63 ± 0.9 yr); 117 Caucasians (64 ± 0.8 yr), 54 AA (61 ± 1.0 yr), 10 others (62 ± 2.0 yr)] were studied before and after a ST program. All subjects underwent a phone-screening interview, received medical clearance from their primary care physician and completed a detailed medical history prior to participating in this study. They were nonsmokers, free of significant cardiovascular, metabolic, or musculoskeletal disorders that would affect their ability to safely perform heavy resistance exercise. Subjects who were already taking medications for at least three weeks prior to the start of the study were permitted into the study provided they did not change medications or dosages at any time throughout the study. After all methods and procedures were explained, subjects read and signed a written consent form, which was approved by the Institutional Review Board of the University of Maryland, College Park. All subjects were reminded throughout the study not to alter physical activity levels or dietary habits for the duration of the study. Body weight was monitored weekly throughout the study to ensure compliance in maintaining a stable diet. All subject information is kept confidential.

Muscular Strength

One-repetition maximum (1-RM) strength test. The 1-RM strength test was performed for both legs on a knee extension (KE) exercise before and after a unilateral (one-legged) KE ST program, using an air-powered resistance machine (Keiser A-300 Leg Extension machine, Keiser Sports/Health Equip. Co., Inc., Fresno, CA). Before

the ST program and the 1-RM test, subjects performed at least one familiarization session in which they completed the training program exercise with little or no resistance and were instructed on proper warm-up, stretching, and exercise technique. This low-resistance training session was conducted in order to familiarize the subjects with the equipment, help prevent injuries and reduce muscle soreness from strength testing and ST. Furthermore, the familiarization helped to control for 1-RM increases due to skill (motor learning) acquisition during the initial stages of training. After a warm-up consisting of two minutes of light cycling, subjects were positioned with a pelvis strap to minimize the involvement of other muscle groups. Arms were placed either across their chest or on their thighs during exercise, but positioning was consistent from pre- to post-testing within subjects. The 1-RM was achieved by gradually increasing the resistance after each successful repetition until the maximal load was obtained. A light system was used to indicate a successful attempt when the knee was extended to the full range of motion (ROM). For each leg, approximately the same number of trials (6-8) and similar rest periods between trials (~1 min) were used to reach the 1-RM after training as before training. Subjects rating of perceived exertion and pain/discomfort were monitored and recorded throughout the test. Standardized procedures with consistency of seat adjustment, body position, and level of vocal encouragement were used.

Regional Body Composition Assessment

Computed Tomography (CT). To quantify quadriceps MV, CT imaging of the trained and untrained thighs was performed (GE Lightspeed Qxi, General Electric, Milwaukee) at baseline and during the final week of the 10-week unilateral ST

program. Comparisons to cadaver measurements have demonstrated that CT measurements provide valid assessments of leg adipose tissue-free skeletal muscle ($r = .97$) and subcutaneous adipose tissue ($r = .99$) (81).

Axial sections of both thighs were obtained starting at the most distal point of the ischial tuberosity down to the most proximal part of the patella while subjects were in a supine position. Section thickness was fixed at 10-mm, with 40-mm separating each section, based on previous work in our laboratory by Tracy et al. (137). Quadriceps MV was estimated using a 4-cm interval between the center of each section. Each CT image was obtained at 120 kVp with the scanning time set of 1 s at 40 mA. A 48-cm field of view and a 512 X 512 matrix were used to obtain a pixel resolution of 0.94-mm. Using MIPAV software (NIH, Bethesda), technicians analyzed CT scans for each subject. They were blinded to subject identification, date of scan, and training status, for both baseline and post-training scans. For each axial section, the cross-sectional area (CSA) of the quadriceps muscle group was manually outlined as a region of interest. The quadriceps CSA was outlined in every 10-mm axial image from the first section closest to the superior border of the patella to a point where the quadriceps muscle group is no longer reliably distinguishable from the adductor and hip flexor groups. The same number of sections proximal from the patella was measured for a particular subject before and after training to ensure within-subject measurement replication. Final MV was calculated using the truncated cone formula as reported by Tracy et al. (137) and described by Ross et al. (108). Based on previous work in our lab (15) combined with recent analysis, coefficients of variation (CV) were calculated for each of three investigators, based on repeated measures of

selected axial sections of one subject on two separate days. Signifying within-investigator reliability, average intra-investigator CV was 1.6%.

To quantify mid-thigh SCF and IMF CSA, CT imaging of the trained and untrained mid-thighs was performed at baseline and during the last week of the 10-week unilateral ST program. Mid-thigh was defined as the mid-point of the most distal end of the ischial tuberosity and the most proximal part of the patella, while subjects were in a supine position. After the mid-thigh slice was selected, the same number of sections proximal from the patella was selected for the after training assessments to ensure identical within subject measurement replication. The CT equipment, section thickness, and imaging procedure were the same as for MV measurements.

Using MIPAV software a blinded technician analyzed CT images for each subject. For each scan, the technician manually outlined the entire mid-thigh and the deep fascial plane surrounding the thigh muscles. The program then provided calculated areas within the outlined regions. SCF at the mid-thigh was assessed by subtracting the area inside the deep fascial plane from the entire area of the mid-thigh. Bone marrow fat and intramuscular fat area were unable to be excluded in this analyses, thus the area inside the deep fascial plane included these components. Repeated measurement CV was calculated for each investigator based on 10 repeated measures of a selected axial selection of one subject on two separate days. Average intra-investigator SCF CSA CV from two investigators was 0.86%.

The IMF was distinguished from the SCF by manually drawing a line along the deep fascial plane surrounding the thigh muscles with the exclusion of bone

marrow fat (39). The IMF was then segmented into a separate image, in which it was identified based on Hounsfield Units (HU) where IMF ranged from -190 to -30, as previously described (39; 61). The CV of repeated measurements for IMF was less than 5% (150).

Training-induced changes were calculated by subtracting the differences between pre- and post-test measures in the control leg from those in the trained leg. Measurements in the untrained leg served as a control for variation of MV, SCF, and IMF CSA due to seasonal, methodological, motivational, attention, biological and genetic factors.

Muscle Quality Calculation

The 1-RM value in kilograms of the dominant leg was divided by the MV of the dominant leg to determine the MQ value, similar to previous work by Ivey et al. (51). MQ in this case is therefore representative of strength per unit of MV (kg/cm^3).

Total Body Composition Assessment

Dual–energy x-ray absorptiometry (DXA). Body composition was estimated by DXA using the fan-beam technology (model QDR 4500A, Hologic, Waltham, MA). A total body scan was performed at baseline and again within a week after the ST program. A standardized procedure for patient positioning and utilization of the QDR software was used. Total body fat-free mass (FFM), fat mass, and percent (%) fat were analyzed using Hologic version 8.21 software for tissue area assessment. Total body FFM was defined as lean soft tissue mass plus total body bone mineral content. The CV's for all DXA measures of body composition were calculated from repeated scans of 10 subjects who were scanned three consecutive times with

repositioning. The CV was 0.6 % for FFM and 1.0% for % fat (15). The scanner was calibrated daily against a spine calibration block and step phantom block supplied by the manufacturer. In addition, a whole body phantom was scanned weekly to assess any machine drift over time.

Body weight was measured to the nearest 0.1 kg with subjects dressed in medical scrubs, and height was measured to the nearest 0.1 cm using a stadiometer (Harpenden, Holtain, Wales, UK). Body mass index (BMI) was calculated as weight (kg) divided by height (m) squared.

Training Program

The training program consisted of unilateral training of the knee extensors of the dominant leg, three times per week, for ~10 weeks. This protocol has been demonstrated to effectively increase knee extensor strength and MV in sedentary men and women, 65-75 years of age (50; 51; 67; 136; 137). Training was performed on a Keiser A-300 air powered KE machine, which allowed for ease of changing the resistance without interrupting the cadence of the exercise. The untrained control leg was kept in a relaxed position throughout the training program.

Following a light warm-up (~ 2 min) on a stationary bicycle, the training consisted of five sets of knee extension exercise for those < 75 years of age and four sets for those ≥ 75 years of age. We did not have subjects ≥ 75 years of age perform the last set because of concern that performing 50 repetitions at near maximal effort for this age group would cause overtraining (96), possibly resulting in a reduction of strength gains (25). The protocol was designed to combine heavy resistance with high volume, while eliciting near maximal effort on all repetitions. The first set was

considered a warm-up set and consisted of five repetitions at 50% of the previously determined 1-RM strength value. The second set consisted of five repetitions at the current 5 RM value. The 5 RM value was originally set to 85% of the 1-RM and was increased continually throughout the training program to reflect increases in strength. The first four or five repetitions of the third set were performed at the current 5 RM value, then the resistance was lowered just enough to complete one or two more repetitions before reaching muscular fatigue. This process was repeated until a total of 10 repetitions were completed. This same procedure was used for the fourth and fifth sets, but the total number of repetitions was increased in these sets to 15 and 20, respectively. The second, third, fourth, and fifth sets were preceded by rest periods lasting 30, 90, 150, and 180 seconds, respectively. A red light indicator was visible to the participant and flashed only when the full ROM was reached. The shortening phase of the exercise (formerly called concentric phase) was performed in approximately two seconds, and the lengthening phase (formerly called eccentric phase) lasted approximately three seconds. A seat belt was worn throughout the exercise session and subjects placed their arms across their chest during exercise in order to minimize involvement of assisting muscles. Subjects performed supervised stretching of the knee extensors and knee flexors following each training session. Trained research assistants carefully monitored the workouts of each participant for every training session during the ~10 weeks of training. They adjusted the resistance accordingly within the set and for the following training session in order to ensure each repetition was performed using the proper resistance and form through the full ROM.

Statistical Analysis

All statistical analysis was performed with SAS software (SAS version 9.1, SAS institute, Inc., Cary NC). For each dependent variable, assumptions of normality were satisfied for residuals and the large sample size allowed the analysis of covariance (ANCOVA) to be robust for deviations from the assumption of equal variance. Pearson correlations were used to determine covariates which were analyzed because of their potential for having physiological effects on MV, SCF, and IMF. The change in MV, SCF, and IMF was calculated by subtracting the change with ST in the untrained leg from the change in the trained leg. A pairwise means comparison test using bonferroni adjustments was used when necessary to determine specific differences between groups of unequal sample size. Statistical significance was set at $P < .05$ and data comparisons were expressed as adjusted means ± SE.

Hypothesis 1. The influence of ST on MV was determined by a one-way ANCOVA. Age, BMI change, baseline lean mass, and anti-inflammatory use were significantly correlated with the dependent variable, and thus were added to the model as covariates. The ANCOVA was one-tailed due to the directional hypothesis.

Hypothesis 2. The influence of sex (men vs. women) and race (Caucasian vs. AA vs. others), along with the interaction of the two, on the response MV had with ST was determined by a 2 x 3 (sex x race) ANCOVA. The same covariates used in *hypothesis 1* were added to this model. The multi-way ANCOVA was one-tailed due to the directional hypothesis.

Hypothesis 3. The influence of ST on both mid-thigh SCF and IMF was determined by a one-way ANCOVA for each dependent variable. Age (only for SCF), BMI change, and baseline % fat were significantly correlated with the dependent variables, and thus were added to the model as covariates.

Hypothesis 4. The influence of sex (men vs. women) and race (Caucasian vs. AA vs. others), along with the interaction of the two, on the response mid-thigh SCF and IMF had with ST was determined by a 2 x 3 (sex x race) ANCOVA. The same covariates used in *hypothesis 3* were added to this model. The multi-way ANCOVA was one-tailed due to the directional hypothesis.

RESULTS

Subject Characteristics

Table 1 displays the physical characteristics before and after the ST program for all subjects combined and for men and women separately. Although there was a small, but significant decrease in % fat for the overall group, there was no significant change in men and a 1.5 ± 0.5% (0.6 of a unit) decrease ($P < 0.05$) in women with ST. There was also a small, but significant increase in total body FFM for the overall group ($P < 0.05$), but no significant difference between men and women's response. Muscle strength (1-RM) and MQ increased significantly with ST for the overall group, and for both men and women analyzed separately (all $P < 0.001$). Men increased their 1-RM strength by 22 ± 1% ($P < 0.001$) compared to a 24 ± 2% increase in women ($P < 0.001$). Despite this slightly higher relative (%) mean difference for women, the men displayed significantly greater 1-RM increases in absolute terms ($P < 0.01$). There were no significant differences between men and women in ST-induced MQ increases.

Table 2 shows the physical characteristics before and after the ST program for Caucasians, AA, and other racial groups. Only the latter group showed a significant decrease in % fat ($P < 0.05$), whereas the only racial group to show a significant increase (1.0 ± 0.4%) in FFM was AA ($P < 0.05$). All three racial groups increased knee extensor strength (24 ± 1% in Caucasians, 23 ± 2% in AA, and 17 ± 4% in others, $P < 0.001$) and MQ (19 ± 2% in Caucasians, 16 ± 3% in AA, both $P < 0.001$, and 13 ± 4% in others, $P < 0.05$). AA had a significantly greater absolute increase in strength than others ($P < 0.05$).

Sex Differences in Regional Body Composition Responses to ST

When all participants were combined, MV increased significantly more ($P < 0.001$) with ST in the trained leg (129.3 ± 4.2 cm^3) than the untrained leg (4.8 ± 4.2 cm^3), as expected. However, changes from baseline to after ST in the trained leg were not significantly different than those of the untrained leg for either SCF (0.05 ± 0.3 vs. -0.6 ± 0.3 cm^2, $P = 0.15$) or IMF (-1.4 ± 0.6 vs. -1.3 ± 0.6 cm^2, $P = 0.9$). For MV analysis, the covariates used in all models were age, change in BMI with training, baseline FFM, and anti-inflammatory medication. Significant covariates for SCF were age, change in BMI with training, and baseline % fat. Change in BMI and baseline % fat were significant IMF covariates while age was not.

Table 3 presents the differences between the trained and untrained leg for MV, SCF, and IMF before and after the ST program, when participants are grouped by sex (men vs. women). At baseline, there were no significant differences between the trained and untrained leg in men or women for MV, SCF, or IMF. When using MV values obtained from subtracting the changes in the knee extensors of the untrained leg from those of the trained leg, the training-induced increase in absolute MV was significantly greater in men (149.6 ± 12.1 cm^3) than women (94.4 ± 12.5 cm^3, $P < 0.01$). There were no within sex changes or between sex differences for SCF and IMF when using the untrained leg as a control.

Race Differences in Regional Body Composition Responses to ST

Table 4 displays the differences between the trained and untrained leg in MV, SCF, and IMF before and after the ST program, when participants are grouped by race. There were no significant race differences at baseline in any of the three

measures of regional body composition in the trained or untrained leg. Within each racial group, the change in the trained leg MV was significantly greater than the change in the untrained leg ($P < 0.001$), as expected. However, when using the untrained leg as a control, there were no significant differences between races in MV change. When covariates were removed from analysis and the alpha level was unadjusted, the change in MV in the trained leg minus the change in the untrained leg was significantly greater in AA compared to others ($P < 0.05$).

There were no significant within race changes in SCF or IMF when controlling for the untrained leg. Additionally, there were no significant differences between races in SCF and IMF change with ST. When covariates were removed from analysis and the alpha level was unadjusted, the only significant ($P < 0.05$) between race difference in SCF or IMF change was among AA, who showed an overall increase ($0.6 \pm .3$ cm^2) in SCF, and others, who demonstrated an overall decrease (-1.2 ± 1.2 cm^2). Because neither race group changed SCF significantly with training, this difference may not be meaningful. There were no significant interactions (sex x race) for ST-induced changes in MV, SCF, or IMF.

DISCUSSION

To our knowledge, this is the first study to examine the influence of both sex and race differences on the effects of ST on MV, SCF, and IMF. The results support our hypothesis that ST increases quadriceps MV to a greater absolute extent in men than in women, independent of race. However, despite the significantly greater hypertrophic effect in men, ST induces substantial muscle hypertrophy over a relatively short period of time in both men and women, in all races studied. Contrary to our hypothesis, sex or racial differences did not influence SCF or IMF response to ST. Even when all subjects were combined into one group, there was no significant reduction in SCF or IMF when changes in the untrained leg were subtracted from those of the trained leg. Thus, high volume, heavy resistance unilateral ST does not appear to affect SCF or IMF, regardless of sex nor race.

Maintaining reduced levels of fat in and around the muscle is important for the aging population because of its association with metabolic disorders and functional disabilities (37; 39; 143; 144). Fat infiltration in and around muscle is a well established consequence of sarcopenia, but despite ST serving as a common intervention for the prevention and treatment of the consequences of sarcopenia (49; 109), information is lacking on the effects of ST on fat infiltration. Given that there is evidence that full body ST increases energy requirements (11) and RMR (97), in addition to decreasing total (140) and regional (138) body fat mass, it seems reasonable to hypothesize that this training modality could lead to reductions in SCF and IMF. In fact, Ross and coworkers concluded that both aerobic training and ST are effective in reducing regional fat stores after they found SCF measured by magnetic

resonance imaging (MRI) decreased in upper and lower body compartments similarly between training modalities when combined with a controlled diet (107; 108). Early work by Havel et al. (46) suggested that adipose tissue cells in close anatomical relation to muscle (i.e. SCF and IMF) may be able to supply FFA to muscle by simple diffusion. Moreover, intramuscular fat oxidation increases during continuous muscle contraction (116; 151), yet prior to the present study, there were no reports to our knowledge that determined the effects of a controlled ST protocol on SCF and only limited information on IMF. In the present study, we hypothesized that men would experience greater losses of these fat depots than women because of their more favorable increase in resting metabolic rate (RMR) with ST (68) and their larger reductions in intramuscular lipid during aerobic exercise (151), reported previously. Since no longitudinal studies were available that analyzed the race influence on ST-induced changes, cross-sectional data showing a lower relative total daily energy expenditure, RMR (12), and fat oxidation rate (91) in AA were used to hypothesize a greater decrease in these specific fat markers with ST in Caucasians.

Because potential mechanisms for changes in fat depots were not part of the research design in the present study, we cannot determine why the ST program did not result in significant reductions in mid-thigh SCF or IMF in the entire group or within sex or racial groups. Nevertheless, it is possible that the ST protocol elicited too low of an energy expenditure to account for a high enough caloric deficit to result in a significant loss of regional fat. The total exercise time, excluding rest periods, was less than five minutes of a training modality that uses primarily anaerobic energy sources during bouts of repeat contractions (33). Although ST can increase resting

levels of norepinepherine (97), which stimulates lipolysis (7), there is no evidence that it causes substantial elevations in free fatty acid (FFA) oxidation, which is required for total body or regional fat loss. We also observed previously that ST-induced reductions in IMF can occur, but they are genotype dependent (150).

It could be argued that the volume of training targeted to the muscle group being analyzed in the present study is greater than those of previous studies demonstrating reductions in regional fat composition (138; 140). However, the volume of the trained musculature may not be as important as the total metabolic cost of the training program if FFA mobilized from SCF and IMF must go through general systemic circulation prior to being oxidized by the muscle. Previous reports from our laboratory (68; 97) and elsewhere (11) show that elevations in RMR with ST are achievable, but these studies used full body ST protocols. It is also possible that the smaller muscle mass involvement in the current study training program may have precluded an increase in RMR, which could provide at least a partial explanation for reductions in localized fat in older women (138) and men (140) with ST in previous studies. Increases in RMR could potentially lead to greater total FFA oxidation, accounting for a greater reduction of both local and total fat. However, this remains speculative until more data is available to address this issue.

Nevertheless, the single leg training protocol used in the present study should theoretically serve as a good model to test the local fat reduction with ST hypothesis. The use of the untrained leg adds a unique level of experimental control by controlling for normal drift in values due to deviations in methodology, biology, yearly seasons, genetic factors, and variations in attention and motivation between experimental and

control groups. Therefore, we have recommended this type of experimental protocol to isolate the independent effects of ST (136). The intent was that the low total caloric expenditure would help rule out any effects on local fat attributed to total fat losses elicited from higher caloric expenditure training. Our finding of a statistically significant reduction in total body % fat would appear to complicate this intent, but the change was extremely small, and the fact that SCF and IMF did not change significantly with ST makes this issue no longer relevant.

In contrast to our findings of a sex difference in the muscle mass change with ST, Hakkinen et al. observed similar increases in quadriceps femoris CSA between men and women, aged 43-75 yrs, following a 12-week full body ST protocol that included unilateral KE and knee flexion (45). Furthermore, McCartney et al. (76) found no independent effects of sex on the increase in quadriceps CSA in older adults following 10 months of progressive full body ST. However, these investigations did not evaluate the volume of the entire trained muscle group as was done in the present study. Muscle hypertrophy has been shown to vary depending on the muscle region examined (87), thus measures of the trained muscle volume are recommended (69). Investigators from our group used MRI to demonstrate similar percent changes in MV between sex groups following a ST protocol similar to the current one (136), as well as one employing full body ST (110). Where reported in the above studies (76; 110; 136), absolute increases in muscle size were greater in older men than older women, yet this difference was only shown to be statistically significant by Tracy et al. (136). It is unclear whether these discrepancies could be explained by variation in statistical analysis, statistical power due to sample size differences, or other design issues.

Variation in training duration, number of exercises, number of sets, number of exercise repetitions, level of resistance, and length of rest periods does exist and may explain some of the differences between studies.

While ST has been shown to elicit significant increases in muscle mass in various age groups of men and women independently (9; 11; 23; 51; 122), no reports have directly compared men and women of advancing age with a sample size comparable to the present study and a design that controls for threats to internal validity. Even so, the presence of a sex difference in response to ST was expected because Ivey et al. (50), from our lab using an identical ST protocol and analysis (difference in change values between the trained and untrained limbs), but with a much smaller sample size, demonstrated a significantly greater increase in MV in young and older men than women. Yet, when subjects were separated in that study by age, the difference between older men and women only approached significance (P = 0.057) (50). Thus, with the added statistical power, our data suggests that middle-aged and older men do indeed increase absolute MV to a greater extent than similarly aged women.

To our knowledge, this is the first study to examine the racial influence on the MV response to ST. We hypothesized that AA would increase their MV to a greater extent than Caucasians because young AA males have a greater relative amount of type IIa muscle fibers than Caucasian males (6). Type IIa fibers were likely the predominant fiber type recruited and activated during training by this ST protocol. However, our data failed to support our hypothesis by showing that race does not significantly alter muscle size response to ST in middle-aged and older adults. There

remains a need to study whether this lack of race effect is present for ST-induced change in functional performances important for physical activities of daily living.

There were several limitations to the present study. For example, there was a wide age range (50 to 85 yrs), and the AA were significantly younger than Caucasians. It is possible that the younger subjects in the study could have different training responses than the older ones. However, age was included as a covariate in our analysis for MV and SCF, but not IMF because of the lack of correlation to change with ST in that variable. Another limitation was the lack of a regulated diet between subjects. While subjects were instructed not to alter their diet or weight throughout the study, the relative consumption of different macronutrients was not controlled. Also, although training was restricted to the quadriceps muscle group, a portion of the fat measured fell into the adjoining hamstrings muscle group. However, it is unlikely these factors would affect the trained leg differently than the untrained.

In conclusion, it appears that the effects of ST on MV, SCF, and IMF are not affected by race, and SCF and IMF are not affected by sex differences in middle-aged and older adults. The data confirms one previous report from our lab that men increase absolute MV to a greater degree than women with ST, though both sexes increase muscle mass significantly with ST. Given that race unlikely influences the ST-induced changes in regional body composition, further examination should attempt to determine if race plays a role on the functional or metabolic changes associated with ST.

Table 1. *Physical characteristics at baseline and after strength training (ST) in men & women combined (overall) and separated.*

	Overall (N = 171-181)[¶]		Men (N = 78-82)[¶]		Women (N = 92-99)[¶]	
	Baseline	After ST	Baseline	After ST	Baseline	After ST
Age (yr)	63 ± 1	--	63 ± 1	--	63 ± 1	--
Height (cm)	168.1 ± 0.7	--	174.8 ± 0.8	--	162.3 ± 0.6	--
Body Mass (kg)	80.6 ± 1.2	80.8 ± 1.2	88.2 ± 1.5	88.3 ± 1.5	74.4 ± 1.6	74.6 ± 1.6
BMI (kg/m^2)	28.5 ± 0.4	28.6 ± 0.4	28.9 ± 0.5	29 ± 0.5	28.2 ± 0.6	28.3 ± 0.6
% Fat	34.2 ± 0.6	33.5 ± 0.6[*]	27.9 ± 0.6	27.6 ± 0.6	39.3 ± 0.6	38.7 ± 0.6[*]
FFM (kg)	50.5 ± 0.9	51.1 ± 0.9[*]	60.3 ± 0.9	60.8 ± 0.9[*]	42.5 ± 0.7	42.9 ± 0.7[*]
1-RM (kg)	25.4 ± 0.7	31.7 ± 0.8[**]	34.2 ± 0.9	42.2 ± 1.0[**†]	18.1 ± 0.6	23.2 ± 0.6[**]
MQ (kg/cm^3) x 10^{-2}	1.7 ± 0.03	1.9 ± 0.03[**]	1.8 ± 0.04	2.1 ± 0.04[**]	1.5 ± 0.03	1.8 ± 0.03[**]

Values are means ± SE.
[¶]A range of sample sizes are provided to represent the range of subjects who completed baseline and after ST testing for all variables.
cm = centimeters; kg = kilograms; BMI = body mass index; FFM = fat-free mass
1-RM = one-repetition maximum for knee extension in trained leg; MQ = muscle quality in trained leg.
[*]Significantly different than baseline ($P < 0.05$).
[**]Significantly different than baseline ($P < 0.001$).
[†]Within group change in men significantly different than women ($P < 0.01$).

Table 2. *Physical characteristics at baseline and after strength training (ST) in Caucasians, African-Americans, & others.*

	Caucasians (N = 112-117)[¶]		African-Americans (N = 52-54)[¶]		Others (N = 8-10)[¶]	
	Baseline	After ST	Baseline	After ST	Baseline	After ST
Age (yr)	64 ± 1	--	61 ± 1	--	62 ± 2	--
Height (cm)	168.2 ± 0.9	--	168.2 ± 1.1	--	163.8 ± 3.3	--
Body Mass (kg)	79.3 ± 1.5	79.7 ± 1.5	83.8 ± 2.1	84 ± 2.2	79.6 ± 6.6	77.1 ± 6.9
BMI (kg/m^2)	27.9 ± 0.4	28.1 ± 0.5	29.6 ± 0.7	29.7 ± 0.7	29.3 ± 1.8	28.9 ± 1.9
% Fat	34 ± 0.8	33.4 ± 0.8	34.45 ± 1.1	34 ± 1.1	34.6 ± 1.8	33.3 ± 1.9[*]
FFM (kg)	49.7 ± 1	50.4 ± 1.1	52.2 ± 1.5	52.8 ± 1.5[*]	50.3 ± 4.9	51 ± 5.3
1-RM (kg)	24.6 ± 0.9	30.9 ± 1.0[**]	27.6 ± 1.2	34.4 ± 1.4[**†]	23.1 ± 2.3	27.2 ± 2.4[**]
MQ (kg/cm^3) x 10^{-2}	1.7 ± 0.03	2.0 ± 0.03[**]	1.7 ± 0.04	1.9 ± 0.1[**]	1.5 ± 0.1	1.7 ± 0.1[*]

Values are means ± SE.
[¶]A range of sample sizes are provided to represent the range of subjects who completed baseline and after ST testing for each variable.
cm = centimeters; kg = kilograms; BMI = body mass index; FFM = fat-free mass
1-RM = one-repetition maximum for knee extension in trained leg; MQ = muscle quality in trained leg.
[*]Significantly different than baseline ($P < 0.05$).
[**]Significantly different than baseline ($P < 0.001$).
[†]Within group change in African-Americans significantly different than others ($P < 0.05$).

Table 3. *Trained and untrained knee extensor muscle volume, subcutaneous fat, & intermuscular fat before and after strength training (ST) in men and women.*

	Muscle Volume (cm^3)		Subcutaneous Fat (cm^2)		Intermuscular Fat (cm^2)	
	Baseline	After ST	Baseline	After ST	Baseline	After ST
Men (N = 74-77)[¶]						
Trained leg	1597.7 ± 32.0	1748.3 ± 35.3[*†]	82.3 ± 4.6	82.1 ± 4.8	69.9 ± 3.7	68.2 ± 3.9
Untrained leg	1549.7 ± 32.9	1551.0 ± 34.3	81.8 ± 4.5	80.8 ± 4.8	68.9 ± 3.7	66.7 ± 3.7
Women (N = 91-94)[¶]						
Trained leg	1378.5 ± 31.3	1486.5 ± 34.6[*]	79.1 ± 4.6	78.9 ± 4.8	44.8 ± 3.6	44.7 ± 3.7
Untrained leg	1372.8 ± 32.1	1387.7 ± 33.7	77.9 ± 4.5	77.4 ± 4.8	44.4 ± 3.6	44.9 ± 3.6

Values are least squares means ± SE.
[¶]A range of sample sizes are provided to represent the range of subjects who completed baseline and after ST testing for all variables.
Muscle volume covariates: age, change in BMI throughout training, baseline FFM, and anti-inflammatory medication.
Subcutaneous fat covariates: age, change in BMI throughout training, and baseline % fat.
Intermuscular fat covariates: change in BMI throughout training and baseline % fat.
[*]Change in the trained leg is significantly greater than change in the untrained leg ($P < 0.001$).
[†]Change in the trained leg minus change in the untrained leg is significantly greater than women ($P < 0.01$).
No significant within or between group changes in SCF or IMF with ST.

Table 4. *Trained and untrained knee extensor muscle volume, subcutaneous fat, & intermuscular fat before and after strength training (ST) in Caucasians, African-Americans, & others.*

	Muscle Volume (cm^3)		Subcutaneous Fat (cm^2)		Intermuscular Fat (cm^2)	
	Baseline	After ST	Baseline	After ST	Baseline	After ST
Caucasians (N = 108-110)[¶]						
Trained leg	1435.6 ± 16.1	1565.4 ± 17.9[*]	79.6 ± 2.7	80.1 ± 2.8	51.0 ± 2.2	50.2 ± 2.2
Untrained leg	1406.5 ± 16.5	1411.2 ± 17.5	78.7 ± 2.7	78.5 ± 2.8	51.1 ± 2.1	50.3 ± 2.1
African-Americans (N = 50-52)[¶]						
Trained leg	1590.8 ± 25.3	1737.0 ± 27.9[*]	94.0 ± 4.0	93.3 ± 4.1	69.3 ± 3.2	66.2 ± 3.3
Untrained leg	1553.4 ± 26.0	1561.9 ± 27.1	92.6 ± 4.0	90.9 ± 4.1	68.8 ± 3.2	66.1 ± 3.1
Others (N = 8-9)[¶]						
Trained leg	1437.8 ± 60.7	1549.7 ± 66.7[*]	68.4 ± 8.9	68.1 ± 9.5	51.8 ± 6.9	52.9 ± 7.3
Untrained leg	1423.9 ± 62.3	1435.0 ± 64.9	68.2 ± 8.8	67.9 ± 9.6	50.0 ± 6.9	50.8 ± 7.0

Values are least squares means ± SE.
[¶]A range of sample sizes are provided to represent the range of subjects who completed baseline and after ST testing for all variables.
Muscle volume covariates: age, change in BMI throughout training, baseline FFM, and anti-inflammatory medication.
Subcutaneous fat covariates: age, change in BMI throughout training, and baseline % fat.
Intermuscular fat covariates: change in BMI throughout training and baseline % fat.
[*]Change in the trained leg is significantly greater than change in the untrained leg ($P < 0.001$).
None of the within group changes in MV were different between racial groups.
No significant within or between group changes in SCF or IMF with ST

APPENDIX A

Research Hypotheses

1. ST will increase quadriceps MV when all subjects are combined into a single group.
2. Men (of both racial groups) and AA (of both sexes) will make greater absolute increases in MV with ST than women (of both racial groups) and Caucasians (of both sexes) respectively.
3. ST will not significantly change mid-thigh SCF or IMF when all subjects are combined into a single group.
4. Men (of both racial groups) and Caucasians (of both sexes) will demonstrate greater absolute decreases in mid-thigh SCF and IMF in response to ST than women (of both racial groups) and AA (of both sexes) respectively.

Significance:

The findings of this study may help identify subpopulations that are more or less likely to improve regional body composition with ST. These results, in combination with other studies on this topic, may help to better individualize exercise prescriptions for middle-aged and older adults. The conclusions of this study should also provide direction for the generation of new hypotheses in future studies.

Delimitations

1. The scope of this study will be delimited to 82 men and 99 women, and 117 Caucasians, 54 AA, and 10 others between the ages of 50 and 85 who volunteered to participate in this study.

2. Participation in the study was delimited to healthy participants free of musculoskeletal or cardiovascular disease who live within 20 minutes of our training facility and who respond to our mailed advertisements of the study

Limitations

1. The participants were volunteers and not randomly selected from the general population. Therefore, the results of this study cannot be generalized to individuals who do not possess characteristics such as age, body size, physical activity, motivation levels, etc. similar to those of the subjects in the study.

2. Subjects self-reported many factors related to health and lifestyle such as physical activity habits, dietary habits, medication levels, and medical conditions. Therefore, it is possible that some self-reports may have been inaccurate. However, it is unlikely that these factors affected the trained leg differently than the untrained.

3. Subjects are asked to maintain diet and activity levels throughout the study. It is possible that one or both of these factors were changed by the participant either consciously or subconsciously. However, it is unlikely that these factors affected the trained leg differently than the untrained.

Operational Definitions

1-RM: The maximal resistance that could be moved a single time through the full ROM with proper form.

5-RM: The maximum resistance that could be moved through the full ROM with proper form only five times.

Cross-sectional area (CSA): The area of a transverse slice at the mid-thigh.

Computed tomography (CT): A technique for assessing regional composition on the examination of axial scans of the thigh. Visual images are created from measurement of the intensity of x-rays and analyzed to measure CSA. The images are based on the attenuation of x-rays as they pass through the body.

Dual-energy x-ray absorptiometry (DXA): A technique for assessing whole and regional body composition that considers the body to be composed of three compartments: bone mineral mass, soft tissue, and lean tissue. Tissue amounts are based on the attenuation of x-rays as they pass through the body.

Fascial plane: Fibrous connective tissue that surrounds the entire muscle. Also known as the epimysium.

Functional abilities: An individual's capacity to perform activities of daily living such as walking up and down a flight of stairs or carrying groceries.

Intramuscular fat: Lipid content within muscle fibers.

Intermuscular fat (IMF): Lipid content within the muscle fascia but between individual muscles.

Lengthening phase: Formally called the eccentric phase. The movement of lowering the lower leg down after the subject reached full ROM on the KE exercise.

Muscle fat infiltration: Determined by the attenuation of muscle tissue. Lower muscle attenuation indicates greater fat infiltration.

Muscle quality (MQ): An estimation of the force production per unit of muscle tissue, determined by dividing the strength of the muscle by the CSA.

Muscle volume (MV): Total quadriceps volume determined by Medical Image Processing, Analysis, and Visualization (MIPAV) software through the utilization of 8-11 axial thigh slices obtained from the CT scan.

Race: Based on definitions from the National Institutes of Health, subjects self-reported themselves under one of six categories.

- American Indian or Alaskan Native: A person having origins in any of the original peoples of North America, and who maintains cultural identification through tribal affiliation or community recognition.
- Asian or Pacific Islander: A person having origins in any of the original peoples of the Far East, Southeast Asia, the Indian subcontinent, or the Pacific Islands. This area includes, for example, China, India, Japan, Korea, the Philippine Islands, and Samoa.
- Black: A person having origins in any of the black racial groups of Africa.
- Hispanic: A person of Mexican, Puerto Rican, Cuban, Central or South American or other Spanish culture or origin, regardless of race.
- White: A person having origins in any of the original peoples of Europe, North Africa, or the Middle East.
- Other/Unknown.

The categories in this classification are social-political constructs and should not be interpreted as being anthropological in nature. For this study, the subject population was defined as Caucasians (Whites), African-Americans (Blacks), and others, which included all individuals who classified themselves as neither White nor Black.

Range of motion (ROM): The full ROM was set at 165 degrees of KE.

Rating of perceived exertion (RPE): A subjective determination of how much effort the subject feels they are exerting. A 6-20 scale was used with 6 being very, very light work, and 20 the hardest possible work.

Regional body composition: Composed of localized muscle mass, bone mass, and fat mass. In this study, MV, SCF, and IMF are the regional body composition variables of interest.

Sarcopenia: The age-related loss of muscle mass.

Sedentary: A depiction of individuals who are not physically active. In this study these individuals are classified as those who, on average, have exercised aerobically for less than 20 minutes per day no more than one time per week and have not performed any type of regular ST over the past six months.

Shortening phase: Formally called the concentric phase. The movement of raising the lower leg until the subject reaches full ROM on the KE exercise.

Subcutaneous fat (SCF): Lipid content between the muscle fascia and the skin.

Unilateral knee extension (KE) exercise: In a seated position, subjects extended their lower leg against a resistance. Only one leg was used while the other leg stayed motion-less.

APPENDIX B: FORMS

CONSENT TO PARTICIPATE IN A RESEARCH PROJECT

Project Title: Effects of Gene Variations on Age- and Strength Training-Induced Changes in Muscular Strength, Body Composition, Blood Pressure, Glucose Metabolism, and Lipoprotein-lipid Profiles

I state that I am over 18 years of age, in good physical health, and have elected to participate in a program of research being conducted by Dr. Ben Hurley in the Department of Kinesiology at the University of Maryland, College Park, MD 20742.

I understand that the primary purpose of this study is to assess the role that genetics may play in causing losses of muscular strength and muscle mass with age and gains in strength and muscle mass as a result of strength training. I understand that another purpose of the study will be to assess the influence of genes on changes in body composition, blood pressure, blood sugar metabolism, blood fats muscle power, and performance of common physical tasks with age and strength training.

I understand that the procedures involve three phases. During the first phase, I will undergo testing, which will include a blood draw to analyze my DNA (genetic material), blood sugar and fats, and other blood proteins. My blood pressure, body composition, bone mineral density, leg muscle volume, muscle strength, muscle power, and ability to complete selected tasks similar to common activities of daily living will also be assessed during this first phase. The second phase of the study involves my participation in a strength training program three times a week for approximately six months. The third and final phase will be a repeat of all previously taken measures, except analysis of my DNA, which will not need to be repeated. Some of the tests will be repeated both after ~ 10 weeks of training and again after the entire training program. These repeat tests will include blood pressure, strength, power, muscle volume and body composition. Other tests will be repeated only after the entire training program.

I understand that the blood draw will require providing about 2 to 3 tablespoons of blood. I understand that there is a risk of bruising, pain and, in rare cases, infection or fainting as a result of blood sampling. However, these risks to me will be minimized by allowing only qualified people to draw my blood. A portion of this blood sample will be sent to the University of Pittsburgh to analyze my DNA. I understand that the remainder will be stored at the University of Maryland for later analysis of my blood sugar, the hormone that regulates my blood sugar (insulin), blood fats, and other blood proteins. I understand that a portion of this sample may also be used for potential future studies, but only as such studies examine strength, body composition (i.e., fat, muscle & bone), metabolism of blood sugar, and blood pressure. I understand that I may contact the principal investigator at any future point in time to request that any stored blood sample be destroyed immediately.

I understand that while I am lying on a padded table, my leg muscle and fat mass will be measured by computed tomography (CT). The CT scan will be performed at Washington Adventist Hospital. My percent body fat and bone mineral density measurements will be performed at the United States Department of Agriculture in Beltsville, Maryland by dual-energy x-ray absorptiometry (DXA). This will require my lying still on a padded exam table wearing metal-free clothing for about 10 minutes at a time, totaling less than 30 total minutes for the entire procedure.

I understand that there will be a total radiation dose of no more than 1 Rem to the whole body (effective dose equivalent) from each CT scan. This amount is well below the maximal annual radiation dose (5 Rems) allowed for exposure in the workplace. The body composition and bone density testing completed by DXA involves a small radiation exposure. The radiation exposure I will receive from DXA is equal t to an exposure of less than 50 millirems to the whole body. Naturally occurring radiation (cosmic radiation, radon, etc.) produces whole body radiation of about 300 millirems per year. Therefore, the total dose of radiation exposure due to the DXA measurement is minimal and the combined dose of DXA and CT is considered low.

I understand that strength and power assessments will be performed on machines that measure how much force and how fast I can exert force through a typical range of knee extension motion. Strength testing will also be performed on the same exercise machines used for training by measuring the maximal amount of force that I can move through the full range of an exercise. During each strength training session I will be asked to exercise on machines which offer resistance against extending and flexing my arms, legs, and trunk region for approximately 40 minutes or less a day, three times a week for up to six months. I understand that I may experience some temporary muscle soreness as a result of the testing sessions. There is also a risk of muscle or skeletal injury from strength and power testing, as well as from strength training. The investigators of this study will use procedures designed to minimize this risk.

I understand that I will be asked to complete some tasks to measure my ability to carry out normal daily activities. These tasks include rising from a chair, short brisk walks and climbing a flight of stairs. Any risk of injury during the completion of these tasks will be minimized by having all sessions supervised by an exercise physiologist qualified to direct this type of testing and wearing a safety harness during the short brisk walks and climbing a flight of stairs.

I understand that it is also possible that heart or blood vessel problems could arise during my participation in the testing or training involved in this study. Although unusual, it is possible that these problems could lead to a heart attack or even death. Therefore, prior evaluation and permission from my physician at my expense will be required to participate in this study. I also understand that it is possible that these risks will not be eliminated completely, even with a medical evaluation prior to participation in the study.

I understand that this study is not designed to help me personally, but may help the investigators better understand who is likely to be most and least susceptible to losing strength, power, and muscle mass with advanced age and who is most and least likely to benefit from strength training.

I understand that my decision of whether or not to participate in this study is voluntary. I understand that I am free to ask questions about this study before I decide whether or not to participate in the study. I understand that if I consent to participate in the study I am free to withdraw from participation at any time without penalty or coercion, or without any requirement that I provide an explanation to anyone of my decision to withdraw. In addition, I understand that refusal to participate will not involve a penalty or loss of benefit to which a volunteer would ordinarily be entitled to at that time. If I am on hormone replacement therapy (HRT) prior to the study, I must remain on them and if I am not on HRT prior to the study, I must remain off them throughout the study to qualify for continued participation. If I am taking other medications prior to the study, I will be permitted to participate as long as I had been on these mediations for at

least 4 weeks prior to the study and do not stop taking them prior to the end of the study. I understand that all information collected in this study is confidential. For my participation in the study I will receive information after the study is completed about my blood pressure, blood test results, bone mineral density, body composition, and functional ability upon request, free of charge. However, I understand that I will not receive any financial compensation in exchange for my participation in this study.

In the event of physical injury resulting from participation in this study, upon my consent, emergency treatment will be available at the medical center of Washington Adventist Hospital with the understanding that any injury that requires medical attention becomes my financial responsibility. I understand that the University of Maryland at College Park will not provide any medical or hospitalization insurance coverage for participants in this research study, nor will they provide compensation for any injury sustained as a result of this research study, except as required by law.

I understand that I can discuss this research study at any time with the principal investigator, Dr. Ben Hurley at (301) 405-2457 or with the study coordinator of this project at (301) 405-2569.

I have read and understand the above information and have been given an adequate opportunity to ask the investigators any questions I have about the study. My questions, if any, have been answered by the investigators to my satisfaction. By my signature I am indicating my decision to consent to participate voluntarily in this study.

Principal investigator: Ben Hurley, Ph.D., Dept of Kinesiology, HLHP Building, University of Maryland, College Park, MD 20742-2611, Ph: (301) 405-2486.

Printed Name of Subject_____

Signature of Subject_____ **Date**_____

Contact information of Institutional Review Board: If you have questions about your rights as a research subject or wish to report a research-related injury, please contact: Institutional Review Board Office, University of Maryland, College Park, MD 20742; e-mail, irb@deans.umd.edu; telephone, 301-405-4212.

Name of Interviewer:_____ Eligible to Participate: ___Yes ___No
Date of Interview: _____ _____Need More Information or Review

University of Maryland at College Park
Department of Kinesiology

THE GUSTO STUDY
Data Sheet for Detailed Subject Telephone Interview

AGE: _____

50 – 64 years	_____
65 or older	_____

o **Brief Explanation of Study**
o **Permission to Conduct Interview?** _____Yes _____No

Comment:_____

o **Contact Information**

Name: Mr. Mrs._____
Address:_____
_____
Phone #:(W)_____(H)_____
E-Mail:_____
Best Way and Time to Contact:_____

- **Time Commitment** – Available
  ____Yes ____No Wants to be contacted after _____(Date) Comment:_____
  _____

- **Proximity to UMD Campus**
  Length of commute: _____ miles or _____ minutes
  Within reasonable commute_____ Willing to make unreasonable commute_____
  Too far to commute_____

- **Age**
  Age: _____ yrsDate of Birth: _____/_____/_____
  MM DD YY
  Approximate Height: _____Approximate Weight: _____

- **Racial Identification:**
  ___ American Indian or Alaskan Native
  ___ Asian or Pacific Islander
  ___ Black, not of Hispanic origin
  ___ Hispanic
  ___ White, not of Hispanic origin
  ___ Other/Unknown

- **Smoking**
  Always Non-Smoker_____ Non-Smoker for _____ Smoker_____

- **Communication Log**
  _____
  _____
  _____
  _____
  _____

Name: _____

- **Physical Activity**

1. Do you do any walking/jogging? _____

Hours per week? _____

Times per week?_____

Speed/Pace?_____

Hills? _____

Do you perspire? _____

2. What household jobs do you do? Gardening, housework, yardwork etc. _____

_____

_____

Hours per week? _____

Times per week?_____

Do you perspire? _____

3. Do you do any recreational activities? Sports, fishing, golfing, yoga, pilates, exercise classes etc.

_____

Hours per week? _____

Times per week?_____

Do you perspire? _____

4. What is your profession? _____

Please describe a typical day at work. _____

_____

_____

How much time each day do you spend walking around?_____

5. Do you lift any heavy objects regularly?_____

6. Is there any aspect of your physical activity that is very inconsistent or sporadic?_____

_____

Relatively Sedentary?

_____Yes _____No

Cardiovascular/Respiratory Conditions

____No ____Yes (Record on Medical History/Treatment Form)

Comments:_____

_____

- **Heart Problems**:

  Did your doctor ever tell you that you had a heart problem? ___Yes ___No

  If yes, what was the date of onset? _____

  What did the doctor call it? (Angina, Heart Failure, Heart attack, Rhythm disturbances, heart murmurs, enlarged heart, diseases of heart valves, others).

  _____

  _____

- **Osteoarthritis/Degenerative Arthritis**

  ___No ___Yes

  If yes, how long and what was the severity_____

  _____

- **High Blood Pressure**

No_____

Yes_____ Controlled (Record High BP and Treatment on Medical History/Treatment Form)

Yes_____ Uncontrolled

Comments:_____

_____

- **Lower Back Pain**

  ___No ___Yes

  If yes, how severe?_____

- **Frailty**

  No Incidents_____

  Fracture as Adult?_____ Describe:_____

  _____

  > 2 Falls in One Year?_____ Describe:_____

  _____

  Comments:_____

  _____

- **Diabetes**

_____No

_____Yes – Type II (Non-Insulin Dependent)

(Record Type II Diabetes and Treatment on Medical History/Treatment Form)

_____Yes – Type I – (Insulin Dependent – not qualified for the GUSTO study)

Comments:_____

_____

- **Orthopedic Conditions**

_____No

_____Yes (Record on Medical History/Treatment Form)

Comments:_____

_____

- **Stroke/Paralytic conditions**

_____Yes ____No. (If yes ask subject if there is any residual weakness of any extremity)

- **Surgical History**

___No ___Yes
If yes, what type (surgeries of the joints, heart surgeries, angioplasty, bypass surgery, Pacemakers)_____
When_____

- **Other Medical Conditions**

_____No
_____Yes (Record on Medical History/Treatment Form)
Comments:_____
_____

- **Information on where to send Physician Consent Form**

Name of Physician: _____
Specialty of Physician:_____
Have you seen your physician within the past 12 months? ____Yes ____No
Phone Number:_____
Fax Number: _____
Address (if phone and fax unknown):_____
_____
_____
(Please explain to the subject that he/she is unlikely to get med clearance if they have not seen their doc within the past 12 months and request them to go to the physician. If willing, request them to let us know after they meet their doctor and fax the med clearance form to physician AFTER they go to their doctor)

- **Summary**

Interviewer Signature: _____

Questions/ Comments:_____
_____
_____

Reviewer Initials: _____

_____Qualifies _____Need More Information
_____Needs Dr. Hurley's Review _____ Disqualified

Questions/ Comments:_____
_____

Medical Clearance to Participate in Research Project

It is my understanding that _____ (name of the volunteer), a patient under my care, has volunteered to participate in the study entitled, ***"Do Genes Influence Responses to Strength Training?"*** The volunteer must have the approval of her or his physician to participate in this study.

Exclusionary criteria for eligibility are listed below. If you believe that your patient named above has any of the medical conditions indicated below, please place a check in front of the condition(s) indicated:

____ Severe cardiovascular disease, such as ____unstable angina, ____uncontrollable hypertension, ____uncontrolled dysrhythmias, ____severe stenotic or regurgitant valvular disease, ____hypertrophic cardiomyopathy, and ____symptomatic peripheral arterial disease
____ Severe COPD or other signs of significant pulmonary dysfunction
____ Intracranial aneurysm
____ Musculoskeletal diseases that cause severe joint pain at rest or upon exertion
____ Diseases that promote muscle protein breakdown
____ Joint, vascular, abdominal or thoracic surgery in the past year
____ History of bone fragility fractures
____ Having any condition that is likely to be aggravated by muscular exertion
____ Being unable to engage safely in mild to moderate exercise, such as independently walking up at least one flight of stairs or walking two blocks on level ground

Although we are unaware of any cardiac complications that have resulted from strength testing or strength training, there is only a limited amount of data available in people over the age of 75. There is one report of non-fatal subarachnoid hemorrhage associated with strength training in three patients who had pre-existing intracranial aneurysms. For this reason, any patient who has known or suspected intracranial aneurysms or who is at high risk for having an intracranial aneurysm, should not participate in this study.

Please check one of the following:
____ Clearance granted
____ Clearance not granted
____ Please send me the following information about the study:

Volunteers in this study will participate in resistance exercise under the supervision of exercise specialists trained specifically for this study under the direction of the Principal Investigator, Ben Hurley Ph.D., Professor, Department of Kinesiology, College of Health and Human Performance, University of Maryland, College Park, Maryland 20742 (email: bh24@umail.umd.edu; tele: 301-405-2486; fax: 301-405-5578).

Physician's signature:_____ Date:_____

Name:_____ **Sex**_____ **Initials:** ___ ___

Name of Interviewer: _____ **Date:** _____

Emergency contact name, address, phone_____

_____

Have you ever been a patient at Washington Adventist Hospital? _____Yes _____No _____not sure

MEDICAL HISTORY FOR GUSTO STUDY

DIRECTIONS:

Read the following questions out loud to each prospective volunteer and check "yes" or "no". Any answers that require qualification should be written in the space below the question or on the back of the sheet.

YES NO

SECTION *A*

Musculoskeletal system:

Have you ever been told by your doctor that you have any of the following?

a. Osteoarthritis or degenerative arthritis ____ ____

b. Rheumatoid arthritis ____ ____

c. Unknown or other type of arthritis (eg: Ankylosing Spondylitis) _____ ____

d. Osteoporosis ____ ____

e. Any other disease of joint or muscle: _____ ____

Comments:_____
_____

SECTION *B*

Cardiovascular system:

1. Has any family member had a heart attack prior to the age of 55? ____ ____

   If so, please describe the relationship:

	YES	NO
2. Have you ever had frequent cramping in your legs?	____	____
If yes, is it a current problem?	____	____
3. Have you ever had pain or cramping in your legs while walking?	____	____
If yes, is it a current problem?	____	____
If yes, is this pain relieved by rest or by discontinuing your walk?	____	____
4. Have you ever been told that you have high blood pressure?	____	____
If yes,		
a. What was the date of diagnosis? _____		
b. Were you given any medications?	____	____
(*Please list the medications with dose on the last page)*		
c. How long have you been on the medications? _____	____	____
d. Has there been a recent change in the medications and if so, when? _____		
5. Did a doctor ever tell you that you had a heart problem?	____	____
If yes,		
a. What was the date of onset?		
b. What did the doctor call it? (eg: Angina, Heart Failure, Heart Attack, Rhythm disturbances, heart murmurs, enlarged heart, diseases of heart valves, others). *Please circle relevant one(s). If others, please ask subject to expl*		
c. Were you given any medications? (*Please list the medications with dose on the last page)*		
d. Was Echocardiography ever done?	____	____
6. Have you ever had any chest pain or discomfort other than breast pain (in women)? or pain and discomfort due to a respiratory or digestive problem?	____	____
If yes,		
a. What was the month and year of the first occurrence? _____		
b. What was the month and year of the most recent occurrence? _____		

c. What was the frequency of occurrence? (eg: once a month, once a week, once a year etc.)

_____

d. How would you describe the pain or discomfort? (Eg: Pressure, Burning,

Squeezing, Piercing, Stabbing, Shooting or Sticking) *Circle appropriate one or if different, please describe*_____

How many minutes did it last?_____

e. Does the pain or discomfort move? If yes, to where?

f. Does the pain or discomfort tend to occur:

After meals-	____	____
At night-	____	____
When Exercising-	____	____
When walking in cold windy weather-	____	____
When upset, excited or nervous-	____	____
Other-		

g. Is this pain relieved by

A change in posture-	____	____
Rest-	____	____
Physical activity-	____	____
Bicarbonate of soda, Tums or antacids-	____	____
Prescribed medications-	____	____
Other-		

h. Did you ever consult a doctor for this pain or discomfort? ____ ____

If yes,

Do you know the diagnosis?_____

Were you given any medications and if so was there a recent change in the medication (within past one month)? (*Please list on last page, if yes*) _____ _____

7. Do you have any history of high cholesterol in your blood as evident by previous blood lipid tests? ____ ____

Comments:_____

_____

SECTION *C* **YES NO**

Respiratory System:

1. Have you ever had persistent cough with sputum production for almost all days for 3 months for two consecutive years? ____ ____

   If yes,

   a. How long did it last?

   b. Did your doctor prescribe any medications and has there been any recent change in the medication:

(*Please list on last page, if any*)

2. Have you ever had attacks of wheezing? ____ ____

   If yes,

   a. Was it seasonal/ periodic? ____ ____

   b. Have you ever-required hospitalization to abort an acute attack? ____ ____

Comments:_____

_____

SECTION *D*

Endocrine system:

Has your doctor ever told you that you have any of the following?

a. Thyroid problems? ____ ____

b. Adrenal problems? ____ ____

c. Diabetes mellitus? ____ ____

   If yes, which type?

Date of onset-_____

Were you on any medication, diet control ____ ____

SECTION *E* **YES NO**

Reproductive system:

Menstrual History

a. Have you attained menopause? ____ ____

If so,

Are you on Hormone Replacement Therapy? ____ ____

If yes, how long have you been on hormone replacement therapy?_____

Comments:_____
_____

SECTION *F* **YES NO**

Neurological system:

1. Do you have any problems with your memory? If yes,
   a. When answering the telephone, do you recall
      what you were doing before it rang? ____ ____
   b. If someone calls you, can you give the directions to your house? ____ ____
   c. Can you keep appointments without a reminder? ____ ____
   d. Can you remember what clothes you wore yesterday? ____ ____

   If the subject answers "no" to any of the above questions

   Do a Mini Mental Status Examination of the subject.
2. Any problems with vision other than corrective lens changes? ____ ____

   If yes, which of the following conditions- Blindness, Temporary loss of vision, Double vision, Glaucoma, Cataract, Macular degeneration or others.

	YES	NO
3. Ringing in your ears?	____	____
4. Vertigo (a feeling of spinning, or unsteadiness)	____	____
5. Fainting Spells (black outs)?	____	____
6. Seizure or convulsions?	____	____
7. Migraine or severe headaches?	____	____
8. Paralysis of arm or leg?	____	____
9. A head injury with loss of consciousness?	____	____
10. Pain, numbness or tingling in your arm or hand?	____	____
11. Pain in your lower back?	_____	____
12. Kidney stones?	_____	____
13. Ruptured vertebral disc in neck or back?	_____	____
14. Have you had pain in any part of body (including headache) while exercising?	_____	____
15. Numbness or pain in your legs?	____	____
16. Have you been told that you have a peripheral neuropathy?	____	____
17. Tremors?	____	____
18. Problems with walking?	____	____
a. Do you fall frequently?	____	____
b. Is your walking problem related to pain, weakness or loss of balance?	____	____
19. Stroke?	____	____
20. Epilepsy?	____	____
21. Operations on skull or brain?	____	____
22. Multiple sclerosis?	____	____
23. Meningitis or Brain fever?	____	____
24. Parkinson's disease	____	____

25. Any history of neurological consultation? ____ ____

Comments:_____

_____

SECTION *H* **YES** **NO**

Hematology/Immunology/Oncology :

1. Have you ever been told by your physician that you had a problem with anemia or any disease of the red blood cells or the white blood cells? ____ ____
2. Any family history of this problem? ____ ____
3. Do you have any history of bleeding disorders? ____ ____
4. Have you ever been diagnosed as having cancer? ____ ____

   If yes, which organ, date of onset? _____
5. Were you given any medications, radiation or undergone any surgery? ____ ____

Comments:_____

_____

SECTION *I*

Surgical History:

Have you undergone any surgeries? (Please include abdominal surgery) _____ _____

If yes,

a. Where and for what purpose? _____
b. Date of Surgery? _____
c. Length of stay in hospital _____
d. Any complications of Surgery? _____

Comments:_____

_____

Has a doctor ever told that you have been suffering from

a) Cystic medial degeneration _____ _____

b) Any Connective tissue disorder? _____ _____

Has any of your family member had an intracranial aneurysm or bleeding? _____ _____

Have you ever been diagnosed with an abdominal aneurysm? _____ _____

History of severe pain in the abdomen? _____ _____

If yes, Please specify_____

Any history of severe headache? _____ _____

If Yes,

What was the date of onset?_____

Was it associated with neurological signs like blurred vision, nausea/vomiting, seizures, drowsiness,memory impairment,sensory or motor loss(weakness)? _____ _____

Was it a new or different type of headache other than tension, migraine etc? _____ _____

Was it the worst ever experienced? _____ _____

Did it occur after exertion, coughing or straining? _____ _____

SECTION *J*

Do you have any other health problems not covered in this questionnaire? ____ ____

If yes, please do specify.

Comments:_____
_____

Subject Name:_____ Initials: __ __ __ #: __ __ __ __ __

GUSTO

PHYSICAL ACTIVITY SCALE

(PASE)

INSTRUCTIONS:

Please complete this questionnaire by either circling the correct response or filling in the blank. Here is an example:

During the past 7 days, how often have you seen the sun?

(0) NEVER (1) SELDOM (1-2 DAYS) (2) SOMETIMES (3-4 DAYS) (3) OFTEN (5-7 DAYS)

Answer all items as accurately as possible. All information is strictly confidential.

Initials: __ __ __ #: __ __ __ __ __

LEISURE TIME ACTIVITY

1. Over the past 7 days how often did you participate in sitting activities such as reading, watching TV or doing handcrafts?

(0) NEVER	(1) SELDOM	(2) SOMETIMES	(3) OFTEN
↓	(1-2 DAYS)	(3-4 DAYS)	(5-7 DAYS)
GO TO Q #2	↓	↓	↓

1a. What were these activities?

_____

1b. On average, how many hours per day did you engage in these sitting activities?

(1) LESS THAN 1 HOUR (2) 1 BUT LESS THAN 2 HOURS

(3) 2-4 HOURS (4) MORE THAN 4 HOURS

2. Over the past 7 days, how often did you take a walk outside your home or yard for any reason? For example, for fun or exercise, walking to work, walking the dog, etc?

(0) NEVER	(1) SELDOM	(2) SOMETIMES	(3) OFTEN
↓	(1-2 DAYS)	(3-4 DAYS)	(5-7 DAYS)
GO TO Q #3	↓	↓	↓

2a. On average, how many hours per day did you spend walking?

(1) LESS THAN 1 HOUR (2) 1 BUT LESS THAN 2 HOURS

(3) 2-4 HOURS (4) MORE THAN 4 HOURS

Initials: __ __ __ #: __ __ __ __ __

3. Over the past 7 days, how often did you engage in light sport or recreational activities such as bowling, golf with a cart, shuffleboard, fishing from a boat or pier or other similar activities? (Do not include walking.)

(0) NEVER	(1) SELDOM (1-2 DAYS)	(2) SOMETIMES (3-4 DAYS)	(3) OFTEN (5-7 DAYS)
↓	↓	↓	↓
GO TO Q #4			

3a. What were these activities?

_____

3b. On average, how many hours per day did you engage in these light sport or recreational activities?

(1) LESS THAN 1 HOUR (2) 1 BUT LESS THAN 2 HOURS

(3) 2-4 HOURS (4) MORE THAN 4 HOURS

4. Over the past 7 days how often did you engage in moderate sport and recreational activities such as doubles tennis, ballroom dancing, hunting, ice skating, golf without a cart, softball or other similar activities? (Do not include walking.)

(0) NEVER	(1) SELDOM (1-2 DAYS)	(2) SOMETIMES (3-4 DAYS)	(3) OFTEN (5-7 DAYS)
↓	↓	↓	↓
GO TO Q #5			

4a. What were these activities?

_____

4b. On average, how many hours per day did you engage in these moderate sport and recreational activities?

(1) LESS THAN 1 HOUR (2) 1 BUT LESS THAN 2 HOURS

(3) 2-4 HOURS (4) MORE THAN 4 HOURS

Initials: _ _ _ #: _ _ _ _ _

5. Over the past 7 days, how often did you engage in strenuous sport and recreational activities such as jogging, swimming, cycling, singles tennis, aerobic dance, skiing (downhill or cross-country) or other similar activities?

(0) NEVER ↓ GO TO Q #6 | (1) SELDOM (1-2 DAYS) ↓ | (2) SOMETIMES (3-4 DAYS) ↓ | (3) OFTEN (5-7 DAYS) ↓

5a. What were these activities?

_____

5b. On average, how many hours per day did you engage in these strenuous sport and recreational activities?

(1) LESS THAN 1 HOUR (2) 1 BUT LESS THAN 2 HOURS

(3) 2-4 HOURS (4) MORE THAN 4 HOURS

6. Over the past 7 days, how often did you do any exercises specifically to increase muscle strength and endurance, such as lifting weights or pushups, etc?

(0) NEVER ↓ GO TO Q #7 | (1) SELDOM (1-2 DAYS) ↓ | (2) SOMETIMES (3-4 DAYS) ↓ | (3) OFTEN (5-7 DAYS) ↓

6a. What were these activities?

_____

6b. On average, how many hours per day did you engage in exercises to increase muscle strength and endurance?

(1) LESS THAN 1 HOUR (2) 1 BUT LESS THAN 2 HOURS

(3) 2-4 HOURS (4) MORE THAN 4 HOURS

Initials: __ __ __ #: __ __ __ __ __

HOUSEHOLD ACTIVITY

7. During the past 7 days, have you done any light housework, such as dusting or washing dishes?

   (1) NO (2) YES

8. During the past 7 days, have you done any heavy housework or chores, such as vacuuming, scrubbing floors, washing windows, or carrying wood?

   (1) NO (2) YES

9. During the past 7 days, did you engage in any of the following activities?

Please answer YES or NO for each item.

		NO	YES
a.	Home repairs like painting, wallpapering, electrical work, etc	1	2
b.	Lawn work or yard care, including snow or leaf removal, wood chopping, etc.	1	2
c.	Outdoor gardening	1	2
d.	Caring for an other person, such as children, dependent spouse, or an other adult	1	2

Initials: __ __ __ #: __ __ __ __ __

WORK-RELATED ACTIVITY

10. During the past 7 days, did you work for pay or as a volunteer?

(1) NO (2) YES
↓

10a. How many hours per week did you work for pay and/or as a volunteer?
_____HOURS

10b. Which of the following categories best describes the amount of physical activity required on your job and/or volunteer work?

(1) Mainly sitting with slight arm movements. (**Examples**: office worker, watchmaker, seated assembly line worker, bus driver, etc.)

(2) Sitting or standing with some walking. (**Examples**: cashier, general office worker, light tool and machinery worker.)

(3) Walking, with some handling of materials generally weighing less 50 pounds. (**Examples**: mailman, waiter/waitress, construction worker, heavy tool and machinery worker.)

(4) Walking and heavy manual work often requiring handling of materials weighing over 50 pounds. (**Examples**: lumberjack, stone mason, farm or general laborer.)

Data Entry Date: _____ Time: _____ GUSTO Team Member Initials: __ __ __
Verification Date: _____ Time: _____GUSTO Team Member Initials: __ __ __

DEXA Body Scan – USDA / University of Maryland
Conway/Hurley/Kostek

Date:_____ Time:_____am/pm

Name:_____ Gender: M / F

Date of Birth:_____

Height:_____ inches _____ cm

Weight:_____ lbs. _____ kg

Subject number:_____

Dominant leg: R / L

Time and composition of last meal (or snack):

_____

_____

_____

_____

Comments:_____

_____

Initials of examiner and DXA technician:_____

The GUSTO Study

"**G**enes **U**nderlying **S**trength **T**raining adaptations in **O**lder adults"

UNIVERSITY OF MARYLAND

College Park

To: Washington Adventist Hospital, Centralized Records & Admitting

Fax #: (301) 891-6149

From: Ben Hurley, Ph.D., Professor, Department of Kinesiology

Fax #: (301) 405-5578 Phone #: (301) 405-2569

RE: Scheduling of patients for CT muscle mass study

Patient Name _____

Previously a patient at Washington Adventist Hospital: ___Yes ___No

Date/Time for CT scan _____ DOB: _____ Age _____ Sex ___

CT scanner: ___ Old scanner ____ Newer scanner ___ Either

Address _____ Phone # _____

_____

_____

Diabetes: __Yes __No If yes, type 1 or type 2? _____ Meds: _____

Scan type: Extremity (bilateral thigh) Contrast: **NO**

Emergency Contact (relationship) _____ Phone # _____

University of Maryland / National Institute on Aging
GUSTO

Symptom-limited Baseline Knee Extension 1-RM

Arms across chest	_____
Seat Belt	_____
Remember to breathe	_____
CHECK EACH LINE BEFORE TEST	

Examiners Name_____
Name_____ Date_____
Time _____ Location_____
Body weight_____ Age_____ Predicted 1-RM_____

Seat_____ Leg_____ Blood Pressure_____ ***Right leg / Left leg***

	Resistance	**P/D scale**	**RPE scale**
Rest	_____	_____	_____
Set 1	___0___	_____	_____
Set 2	_____	_____	_____
Set 3	_____	_____	_____
Set 4	_____	_____	_____
Set 5	_____	_____	_____
Set 6	_____	_____	_____
Set 7	_____	_____	_____
Set 8	_____	_____	_____
Set 9	_____	_____	_____
Set 10	_____	_____	_____
Set 11	_____	_____	_____
Set 12	_____	_____	_____

Most severe P/D: _____ Subject's initials: _____

Post BP_____ 3 min. post BP_____ **Valid** **Invalid**

If invalid, please explain: _____
_____
Notes: _____
_____
_____

Data entry #1:_____initials _____date

Data entry #2:_____initials _____date

University of Maryland / National Institute on Aging
GUSTO

Symptom-limited Post Unilateral Training Knee Extension 1-RM

Arms across chest	____
Seat Belt	____
Remember to breathe	____
CHECK EACH LINE BEFORE TEST	

Examiners Name_____
Name_____ Date_____
Time _____ Location_____
Body weight_____ Age_____ Predicted 1-RM_____

Seat_____ Leg_____ Blood Pressure_____ ***Right leg / Left leg***

Participant's initials indicating that the P/D and RPE scale is understood and that he/she has the right to stop the test at anytime _____

	Resistance	**P/D scale**	**RPE scale**
Rest	_____	_____	_____
Set 1	0	_____	_____
Set 2	_____	_____	_____
Set 3	_____	_____	_____
Set 4	_____	_____	_____
Set 5	_____	_____	_____
Set 6	_____	_____	_____
Set 7	_____	_____	_____
Set 8	_____	_____	_____
Set 9	_____	_____	_____
Set 10	_____	_____	_____
Set 11	_____	_____	_____
Set 12	_____	_____	_____

Most severe P/D: _____ Subject's initials: _____

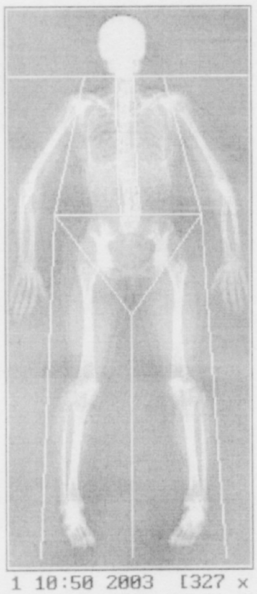
Post BP_____ 3 min. post BP_____ **Valid** **Invalid**

If invalid, please explain: _____
_____
Notes: _____
_____
_____

Data entry #1:_____initials _____date	
Data entry #2:_____initials _____date	

DXA Result Example

HOLOGIC



©May 1 10:50 2003 [327 x 150]
Hologic QDR-4500A (S/N 45816)
Whole Body Fan Beam V8.26a:3*

A11220209 Fri Nov 22 11:34 2002
Name:
Comment: GUSTO post unilateral
I.D.: GUSTO Sex: F
S.S.#: - - Ethnic: W
ZIP Code: Height:5'10"
Operator: MJD Weight: 133
BirthDate: Age: 61
Physician: GUSTO
Image not for diagnostic use
TBAR1790 - 1
F.S. 68.00% 0(10.00)%
Head assumes 17.0% brain fat
LBM 73.2% water

Region	Fat (grams)	Lean+BMC (grams)	% Fat (%)
L Arm	1082.4	2034.7	34.7
R Arm	1104.2	2059.6	34.9
Trunk	6946.6	21128.9	24.7
L Leg	4457.0	6865.2	39.4
R Leg	4287.2	6747.0	38.9
SubTot	17877.4	38835.4	31.5
Head	808.2	3267.2	19.8
TOTAL	18685.6	42102.6	30.7

HOLOGIC

Unilateral Strength Training

BP Questions:
1) Ever been told high Blood Pressure?
   -If yes, taken medication today and yesterday?
2) Heavy meal in past 90 minutes?
3) Had coffee/tea in past 30 minutes?
4) Smoked in past 30 minutes?
5) Any type of exercise in past 30 minutes?

Subject's Name: _____ Seat position _____ 1 RM value ____ Leg ____

Training Session #	FAM I	FAM II	1	2	3	4	5	6			
Date											
Pre-Ex .BP (mm Hg)											
5 RM*Resistance (lbs)											
Peak Ex.BP (mm Hg)											
Post Ex.BP (mm Hg)											
Weight (lbs)											

*= Weight adjusted as needed to maintain 5 RM

Training Session #	10	11	12	13	14	15	16	17	18	19	20
Date											
Pre-Ex .BP (mm Hg)											
5 RM*Resistance (lbs)											
Peak Ex.BP (mm Hg)											
Post Ex.BP (mm Hg)											
Weight (lbs)											

*= Weight adjusted as needed to maintain 5 RM

Training Session #	21	22	23	24	25	26	27	28	29	30	31
Date											
Pre-Ex .BP (mm Hg)											
5 RM*Resistance (lbs)											
Peak Ex.BP (mm Hg)											
Post Ex.BP (mm Hg)											
Weight (lbs)											

*= Weight adjusted as needed to maintain 5 RM

Training

- 5 reps @ 50% of 1 RM resistance- 30 sec rest
- 5 reps @ 5 RM resistance- 1.5 min rest
- ~5reps @ 5 RM resistance, then lower weight just enough to do 1-3 reps, repeat process until 10 total reps -2.5 min rest.
- ~5reps @ 5 RM resistance, then lower weight just enough to do 1-3 reps, repeat process until 15 total reps -3 min rest.
- ~5reps @ 5 RM resistance, then lower weight just enough to do 1-3 reps, repeat process until 20 total reps

1) P/D: ___, ___, ___	2) P/D: ___, ___, ___	3) P/D: ___, ___, ___	4) P/D: ___, ___, ___	5) P/D: ___, ___, ___	6) P/D: ___, ___, ___
7) P/D: ___, ___, ___	8) P/D: ___, ___, ___	9) P/D: ___, ___, ___	10) P/D: ___, ___, ___	11) P/D: ___, ___, ___	12) P/D: ___, ___, ___
13) P/D: ___, ___, ___	14) P/D: ___, ___, ___	15) P/D: ___, ___, ___	16) P/D: ___, ___, ___	17) P/D: ___, ___, ___	18) P/D: ___, ___, ___
19) P/D: ___, ___, ___	20) P/D: ___, ___, ___	21) P/D: ___, ___, ___	22) P/D: ___, ___, ___	23) P/D: ___, ___, ___	24) P/D: ___, ___, ___
25) P/D: ___, ___, ___	26) P/D: ___, ___, ___	27) P/D: ___, ___, ___	28) P/D: ___, ___, ___	29) P/D: ___, ___, ___	30) P/D: ___, ___, ___

Comments/Notes:

*P/D (Pain/Discomfort Scale) taken before training, after Set 2 of training, and immediately after training.

APPENDIX C: RAW DATA

ID #	Age	Sex	Race	Height	Pre Weight	After Weight	Pre body fat %	After body fat %	Pre FFM	After FFM	Pre 1RM	After 1RM	Anti-inflammatory Drug Usage
	yr			cm	grams	grams			grams	grams	kg	kg	1 = yes
HUR 011	71	M	AA	180	89939.9	89890.1	0.25	0.25	64541.9	64245.8	196	292	2
HUR 012	66	F	AA	168.2	70323.1	69935.2	0.37	0.37	41940.1	41956.3	143	180	2
HUR 015	78	F	Caucasian	168.5	87642.3	86919.2	0.48	0.47	43653	44544.8	107	145	2
HUR 016	52	F	AA	156	70965.7	69636.8	0.31	0.36	46503.2	42484.1	146	164	2
HUR 017	80	M	Caucasian	160.5	66387.4	64878	0.22	0.23	49577.6	47532.9	120	156	1
HUR 018	77	M	Caucasian	168.6	78696.3	79607.1	0.28	0.28	53769.9	55103.7	170	200	2
HUR 020	60	F	Other	162	55320.8	54297	0.34	0.32	34773	35259.1	101	102	2
HUR 021	57	F	AA	161	88850.9	90020	0.43	0.40	48979.4	51965.2	108	147	2
HUR 022	70	M	Caucasian	178.9	74022.3	74738.6	0.23	0.23	54075.1	55097.5	184	227	2
HUR 023	61	F	Caucasian	165.1	62561.8	63460.4	0.35	0.35	38680	39215	112	130	2
HUR 024	53	M	AA	161.5	77242.4	78799.6	0.31	0.30	51168.7	52941.6	202	225	2
HUR 025	57	F	Caucasian	169.6	90553.4	93212.9	0.42	0.45	51096.8	49263.5	84	137	2
HUR 026	59	F	AA	172.3	66658.1	66562.2	0.28	0.29	45745.1	45165.1	161	205	2
HUR 027	52	F	Caucasian	161.6	101382	101380	0.47	*	51900.6	*	152	187	2
HUR 028	64	F	Caucasian	160	63705.5	65949.4	0.40	0.35	36067.2	41095.4	95	128	2
HUR 030	57	F	Caucasian	162.56	60360.4	59940.4	0.31	0.29	39681.7	40546	108	136	2
HUR 031	60	F	Caucasian	165	88240.8	89788.6	0.45	0.46	45976.8	45804.6	97	130	2
HUR 032	54	M	Caucasian	168.6	95690.2	95679.2	0.36	0.34	58785.5	60451.6	188	220	2
HUR 033	62	F	Caucasian	178	60538.8	60788.2	0.29	0.31	41187.5	40125.8	132	*	2
HUR 034	65	F	Caucasian	172.7	91013	88722.1	0.41	0.39	51258.5	51375.2	130	160	2
HUR 035	76	F	AA	167.7	79189.9	80885.2	0.40	0.40	44922.7	46593.1	90	108	1
HUR 037	71	F	AA	163.1	62569.4	60584.7	0.27	0.26	44328	43378.8	90	138	1
HUR 038	61	M	Caucasian	164.9	63642.9	64116.6	0.21	0.22	47746.5	47661.2	123	200	2
HUR 039	77	M	Caucasian	179.5	96937.1	99403.6	0.33	0.32	61985.5	64429	165	181	1
HUR 041	63	M	Caucasian	163.7	71623.1	70366.6	0.32	0.31	46526.3	46119.6	117	158	2
HUR 043	68	F	AA	157.5	82344.6	82344.6	0.41	0.40	46051.9	47140.1	112	126	2
HUR 046	59	M	AA	161.8	82986.8	81539	0.23	0.22	61220.4	61070.7	129	160	2
HUR 047	54	M	Caucasian	179.6	93256.4	95524	0.31	0.33	61351.7	61528.7	225	275	2
HUR 048	53	F	Caucasian	168.3	75573	75714.7	0.41	0.40	42448.6	43677.4	110	152	2
HUR 049	77	F	Caucasian	162.56	87446.3	89359.5	0.50	0.48	41968.8	44222	100	100	2
HUR 050	70	M	Caucasian	184	90209.4	91424.7	0.32	0.30	59007.8	60942.8	212	226	1
HUR 051	64	F	AA	165	67487.7	66317.6	0.33	0.33	42064.8	41360.1	150	180	2

ID #	MV Pre (Trained)	SCF Pre (Trained)	IMF Pre (Trained)	MV After (Trained)	SCF After (Trained)	IMF After (Trained)	MV Pre (Untrained)	SCF Pre (Untrained)	IMF Pre (Untrained)	MV After (Untrained)	SCF After (Untrained)	IMF After (Untrained)
	cm^3	cm^2	cm^2	cm^3	cm^2	cm^2	cm^3	cm^2	cm^2	cm^3	cm^2	cm^2
HUR 011	1985.401	36.290	40.850	2148.563	36.932	54.420	1963.090	39.059	38.640	1909.871	37.986	57.550
HUR 012	1226.639	84.533	28.340	1335.184	86.247	25.770	1088.371	86.265	21.760	1047.766	82.257	22.820
HUR 015	1188.245	142.998	32.000	1281.612	138.876	29.000	1097.236	135.158	35.648	1100.210	136.028	29.953
HUR 016	1380.086	76.550	49.795	1407.238	78.091	56.000	1358.207	72.620	42.124	1365.461	77.168	58.535
HUR 017	1321.769	29.312	48.410	1432.596	30.023	23.977	1300.019	27.152	46.336	1223.335	27.659	22.395
HUR 018	1531.456	37.477	69.504	1640.988	38.294	76.043	1585.250	35.736	43.348	1578.204	33.820	46.688
HUR 020	1029.116	67.166	41.238	1083.067	64.450	37.758	1062.687	61.453	45.738	1065.304	59.827	42.996
HUR 021	1278.036	134.824	85.992	1471.644	134.578	95.203	1393.668	133.093	87.785	1410.849	128.839	92.813
HUR 022	1729.187	43.093	24.855	1859.000	40.729	24.223	1473.053	40.254	24.539	1501.059	37.608	24.645
HUR 023	1081.496	71.517	22.641	1183.616	72.633	24.504	1092.759	65.153	23.555	1161.686	69.354	20.672
HUR 024	1580.816	58.825	50.309	1755.459	66.973	47.953	1627.782	64.670	48.410	1578.471	66.384	44.330
HUR 025	979.828	114.126	71.613	1139.653	113.607	83.285	1183.842	111.059	69.117	1208.923	109.608	73.547
HUR 026	1570.259	60.855	57.762	1648.520	60.451	58.113	1487.626	59.458	54.176	1482.958	57.929	54.352
HUR 027	1441.699	222.372	52.418	1524.581	228.639	55.652	1490.291	203.432	51.750	1526.512	195.680	52.910
HUR 028	758.441	120.015	35.156	928.139	114.381	43.559	699.955	108.246	62.965	782.057	105.688	58.816
HUR 030	1265.295	51.530	13.641	1303.076	50.300	12.973	1095.259	50.546	12.410	1094.931	47.180	12.234
HUR 031	1203.357	130.649	67.359	1296.605	131.924	73.582	1024.821	118.521	72.809	1010.661	124.295	87.961
HUR 032	1839.691	69.627	59.590	1997.037	68.722	48.867	1788.609	73.406	53.930	1781.286	74.944	63.035
HUR 033	1245.380	54.422	18.598	1299.208	60.486	18.738	1312.268	56.725	21.727	1314.690	60.697	20.953
HUR 034	1566.181	101.373	104.910	1705.314	90.940	94.043	1556.396	97.392	104.941	1548.196	89.104	108.703
HUR 035	1289.285	71.464	128.180	1304.657	73.793	121.359	1255.017	73.169	134.227	1250.004	77.063	133.805
HUR 037	1251.137	46.028	41.344	1310.536	49.078	40.148	1150.729	54.308	43.805	1142.458	55.081	39.551
HUR 038	1347.379	26.543	20.566	1469.187	27.940	29.672	1427.986	27.914	28.898	1417.282	27.633	26.719
HUR 039	1976.792	44.271	56.250	2053.457	46.705	54.281	1887.317	49.052	61.945	1882.059	49.482	58.465
HUR 041	1425.929	49.605	48.586	1480.346	50.054	53.508	1369.612	49.632	37.688	1381.553	50.748	40.570
HUR 043	1382.599	124.550	34.600	1460.634	122.045	35.332	1375.914	124.163	25.500	1395.784	122.370	28.371
HUR 046	1815.327	38.145	30.164	1908.723	34.875	35.051	1808.365	40.983	27.352	1750.088	37.424	32.168
HUR 047	2349.337	51.267	46.406	2605.081	53.464	46.547	2047.540	51.469	46.863	2095.158	52.418	47.953
HUR 048	1026.550	168.425	49.430	1110.921	174.612	45.703	986.240	159.662	51.152	963.080	164.689	41.871
HUR 049	1125.472	96.724	37.336	1147.963	93.190	30.516	1016.638	93.384	38.848	1036.536	95.563	35.648
HUR 050	*	64.257	46.195	*	59.792	42.434	*	59.906	39.516	*	55.591	36.527
HUR 051	1459.366	89.183	43.031	1498.298	81.694	32.941	1233.879	80.613	41.695	1195.263	78.706	34.102

ID #	Age	Sex	Race	Height	Pre Weight	After Weight	Pre body fat %	After body fat %	Pre FFM	After FFM	Pre 1RM	After 1RM	Anti-inflammatory Drug Usage
HUR 053	67	F	Caucasian	162	94416.3	94769.4	0.47	0.44	48350.5	51117.2	129	142	1
HUR 054	70	M	AA	184.9	89505.4	91042.5	0.28	0.26	61202.9	64130.4	213	*	2
HUR 055	61	F	Caucasian	164.7	66394.4	65610.7	0.40	0.36	38292.3	40314.5	133	170	2
HUR 056	66	F	AA	162.6	59868.2	57862.5	0.34	0.32	37523.1	37532	106	120	2
HUR 061	66	F	Caucasian	161.5	101074	105235	0.42	0.44	56932	56440	74	105	2
HUR 062	69	M	Caucasian	172.7	80039.3	79818.4	0.30	0.29	53677.7	54962.2	185	225	1
HUR 063	66	M	Caucasian	171.2	74817	75012.9	0.31	0.29	49262.1	51118.6	140	170	1
HUR 064	64	M	AA	173.2	81062.4	82761.3	0.20	0.19	61564.7	63630.2	202	250	2
HUR 065	65	M	Caucasian	178	97436.1	97939.1	0.31	0.30	64494.6	65041.5	170	190	2
HUR 066	71	F	Caucasian	160.02	67109.8	67590.1	0.43	0.41	36494	37626	85	103	2
HUR 067	71	M	AA	162	74556.4	75501.9	0.33	0.30	48008.3	50888.3	168	210	1
HUR 068	66	M	Caucasian	178.2	79048.4	79014.5	0.27	0.26	55422.3	56271.1	154	185	2
HUR 070	64	F	AA	156.2	84814.2	86971.7	0.44	0.44	46014.7	47278.8	135	155	2
HUR 071	75	M	Caucasian	172.3	86892.8	87911.8	0.34	0.32	55112.1	56862.4	175	190	1
HUR 073	72	M	Other	176.1	105733	106213	0.37	0.34	63796.5	67330.8	130	170	2
HUR 074	65	F	Caucasian	158.5	63276.4	59043	0.40	0.37	36731.1	36106.8	125	141	2
HUR 075	71	M	Caucasian	172.1	88633.8	85652.2	0.29	0.28	61105.9	59560.3	110	170	2
HUR 076	58	F	Caucasian	160.6	61083.6	60436.7	0.35	0.36	37811.4	36771.7	105	115	2
HUR 077	70	F	Caucasian	156.4	69376	66214.2	0.38	0.37	41379.4	39926.6	87	112	2
HUR 078	71	M	Caucasian	168.9	75222.8	73939.8	0.23	0.22	54741.1	55143	174	212	2
HUR 079	71	M	Caucasian	176.5	93760.5	99227.6	0.31	0.35	61999	62222.8	200	240	2
HUR 080	81	M	Caucasian	171	61158.5	59955.4	0.23	0.22	44855.7	44366.8	91	117	2
HUR 081	83	F	Caucasian	143.7	57818.3	59789.1	0.33	0.34	36852.4	37403.3	65	76	2
HUR 082	68	M	AA	171.5	84053.7	84399.7	0.25	0.25	60307.2	60333.4	146	195	2
HUR 083	71	F	AA	159.5	72876.5	72285	0.43	0.42	39521.8	39909.5	85	114	2
HUR 084	80	F	Caucasian	151.4	55558.6	54711.5	0.32	0.33	36197.4	35251.9	80	95	2
HUR 085	71	M	Caucasian	190.4	114885	114918	0.29	0.30	77826.6	76663.6	175	205	2
HUR 087	62	M	Caucasian	170.8	85002.5	89259.1	0.23	0.25	62967.8	64264.8	245	285	2
HUR 090	69	F	AA	160.4	78527.4	80621.3	0.40	0.42	45206.4	44517.2	122	165	1
HUR 091	60	F	Caucasian	154.94	64982.7	65437	0.42	0.42	36110.2	36390.6	88	103	1
HUR 092	65	M	Caucasian	178.7	77245.6	78766.9	0.23	0.25	55934.7	55577	144	185	2
HUR 093	65	F	Caucasian	162.1	78736	79677.4	0.44	0.47	41592.1	39944.2	100	130	2
HUR 094	65	F	Caucasian	154.7	73192.6	72935.5	0.44	0.46	39266.3	37535.2	119	120	2

ID #	MV Pre (Trained)	SCF Pre (Trained)	IMF Pre (Trained)	MV After (Trained)	SCF After (Trained)	IMF After (Trained)	MV Pre (Untrained)	SCF Pre (Untrained)	IMF Pre (Untrained)	MV After (Untrained)	SCF After (Untrained)	IMF After (Untrained)
HUR 053	1525.528	108.272	102.480	1659.366	103.131	109.617	1490.468	99.563	95.871	1546.507	96.073	87.926
HUR 054	2245.183	39.771	23.098	2372.097	39.384	25.383	2150.560	42.337	27.527	2104.064	42.592	26.613
HUR 055	1286.086	63.193	35.965	1379.688	63.615	33.891	1139.209	67.526	33.609	1091.691	63.343	48.797
HUR 056	1004.034	85.702	38.602	1130.031	89.147	33.539	989.156	94.746	40.957	1007.183	89.209	33.820
HUR 061	1352.010	118.538	110.672	1499.121	124.137	128.953	1218.604	111.190	123.328	1292.680	112.245	129.059
HUR 062	1731.256	39.516	51.855	1986.454	43.611	43.348	1650.703	38.250	47.180	1678.132	38.285	38.848
HUR 063	1403.877	49.474	61.031	1571.370	51.135	56.883	1365.889	51.513	73.512	1435.834	52.638	64.125
HUR 064	1996.723	30.217	45.316	2309.684	33.794	44.156	2105.885	31.351	43.207	2182.438	32.238	43.840
HUR 065	1997.422	32.722	82.512	2122.058	31.184	86.168	1904.439	31.491	76.254	1845.699	30.850	84.586
HUR 066	930.825	92.865	40.816	1026.277	99.773	45.457	916.792	82.037	48.797	869.712	82.538	48.621
HUR 067	1572.301	44.130	71.648	1765.511	45.773	72.387	1410.033	45.879	71.754	1465.689	47.558	69.996
HUR 068	1630.642	67.790	24.080	1692.032	70.840	27.910	1523.686	66.278	22.010	1476.853	67.025	34.100
HUR 070	1215.256	108.176	74.285	1288.528	118.907	62.332	1067.063	99.615	75.445	1042.984	105.082	68.027
HUR 071	1652.872	41.968	53.719	1801.065	47.065	58.992	1602.068	43.682	48.410	1565.271	45.923	48.059
HUR 073	1881.631	87.829	49.641	2039.103	81.668	48.938	1812.627	90.229	57.164	1772.536	89.921	51.469
HUR 074	1211.665	60.521	37.055	1270.268	51.539	30.270	1156.379	54.659	29.426	1134.824	44.754	25.207
HUR 075	1432.844	31.711	61.453	1550.878	29.689	38.109	1461.548	31.746	57.727	1422.524	31.052	59.836
HUR 076	790.023	71.385	42.398	915.990	72.765	41.977	967.071	69.460	43.980	919.382	69.469	44.965
HUR 077	1085.480	110.373	47.426	1138.090	98.490	46.969	975.607	130.210	34.734	965.927	118.266	37.055
HUR 078	1638.033	28.925	27.530	1670.903	28.784	33.360	1599.310	31.764	40.680	1560.933	29.013	43.700
HUR 079	1885.211	40.324	71.016	2036.855	38.294	72.949	1894.344	35.991	81.844	2035.030	37.028	79.383
HUR 080	1185.798	17.534	28.723	1174.801	16.901	24.398	1142.334	19.696	30.375	1087.416	19.055	26.438
HUR 081	789.496	98.112	64.758	854.650	102.621	72.070	903.834	83.927	62.930	906.171	94.676	61.840
HUR 082	1651.739	53.789	47.566	1846.595	52.198	43.980	1943.910	49.395	40.395	1917.179	46.336	41.801
HUR 083	996.066	91.872	77.555	1086.868	86.933	56.707	935.246	95.537	93.516	925.398	93.067	61.980
HUR 084	754.030	72.492	29.570	867.737	69.161	22.820	736.800	76.553	39.200	723.364	69.530	26.370
HUR 085	1968.101	79.831	64.160	2158.394	75.744	61.523	2007.836	79.242	63.668	2069.050	75.797	60.012
HUR 087	1813.644	32.792	43.488	2103.574	34.840	50.449	2011.197	33.697	44.895	1981.376	35.552	53.051
HUR 090	1472.325	148.526	26.650	1621.712	152.139	31.640	1425.251	157.395	26.930	1442.954	165.454	28.510
HUR 091	900.877	121.808	29.250	982.011	105.539	29.848	907.929	119.268	28.090	894.341	105.548	28.828
HUR 092	1625.352	27.035	24.860	1742.219	25.928	49.040	1644.497	27.703	26.330	1591.365	26.314	39.410
HUR 093	974.091	110.883	64.512	1050.203	108.686	45.211	965.046	122.854	66.270	957.530	119.162	49.395
HUR 094	1067.882	126.870	51.363	1170.874	126.378	52.629	1080.979	134.235	54.105	1037.133	125.877	63.141

ID #	Age	Sex	Race	Height	Pre Weight	After Weight	Pre body fat %	After body fat %	Pre FFM	After FFM	Pre 1RM	After 1RM	Anti-inflammatory Drug Usage
HUR 096	70	M	Other	175.5	102330	*	0.32	*	67266.3	*	165	175	1
HUR 097	85	F	Caucasian	155.6	66989.8	68707.4	0.36	0.39	40605.7	39949.2	100	113	2
HUR 098	71	M	Caucasian	174.1	87644.6	87181.6	0.31	0.34	57524.2	54331.6	155	188	1
HUR 099	69	M	Caucasian	178.5	88886.4	*	0.28	*	60375.8	*	220	264	1
HUR100	73	M	Caucasian	175.26	83873.9	*	0.32	*	54339.9	*	153	173	2
HUR105	65	F	Caucasian	170.18	61106.1	61211	0.42	0.39	33604.7	35454.8	78	111	1
HUR 108	59	M	Caucasian	182.2	91133	93822.5	0.39	0.37	52786.7	56694.8	215	227	2
HUR109	62	F	Other	154.94	67238.6	67503.4	0.40	0.38	38424.7	40074.3	140	154	1
HUR110	70	F	Caucasian	158.5	74320.3	72826.9	0.44	0.41	39620	41026.9	72	105	2
HUR112	68	F	AA	*	*	*	*	*	*	*	84	97	2
HUR113	67	M	Caucasian	*	*	78735.3	*	0.23	*	57071.6	110	158	1
HUR114	70	F	Caucasian	157.48	64999.3	64520.5	0.38	0.36	38803.4	39506.8	84	117	2
HUR115	60	M	Caucasian	175.26	78666.1	77282.5	0.20	0.23	59768.1	56722.9	156	195	2
HUR 117	65	M	Caucasian	166.64	63389.2	65437.1	0.17	0.18	49903.3	50989.8	148	170	2
HUR 118	60	F	Caucasian	170.2	73198.1	74140.5	0.40	0.39	42317	43391	80	130	2
HUR 119	57	F	AA	162.56	75753.7	75829.9	0.37	0.37	45763.4	45286	192	205	2
HUR 121	50	M	Other	160.02	86439.1	85856.4	0.29	0.29	58988.1	59067.3	162	175	2
HUR122	56	M	Caucasian	182.88	81670.4	81744.9	0.31	0.31	53812.8	53140.4	180	225	2
HUR 123	82	F	Caucasian	158.1	58076.7	58120	0.34	0.35	36563.5	35794.2	85	118	2
HUR 124	66	F	Caucasian	165.1	65322.4	62286.4	0.34	0.32	41041.7	40365.6	130	142	2
HUR 126	76	F	Caucasian	156.21	70451.5	70470.1	0.44	0.44	37049.5	37240.8	75	85	2
HUR 127	55	M	AA	175.26	125340	122267	0.35	0.34	78840.8	77156.4	270	293	2
HUR 128	52	F	Caucasian	157.48	50479.8	48688.3	0.24	0.24	36154.9	34748.2	105	112	2
HUR 130	50	F	AA	170.18	66322.4	65618.6	0.44	0.43	35201.9	35241.3	75	100	2
HUR 131	64	F	Caucasian	160.02	61819.6	61180.7	0.34	0.35	38772.4	38151.1	82	115	2
HUR 133	51	F	AA	162.56	81350.2	81178.4	0.39	0.38	47350.5	47716.8	158	186	1
HUR 135	64	M	Caucasian	177.8	76631.7	76997.9	0.32	0.30	49860.6	51386.1	165	206	2
HUR 136	54	F	AA	170.18	105183	105387	0.49	0.48	50863.3	52219.6	90	104	2
HUR 137	50	F	AA	167.64	81640.1	82065	0.41	0.40	45942.2	47386.2	118	150	2
HUR 138	64	F	AA	170.18	69346.5	69109.9	0.35	0.37	42766.1	41439.7	120	122	2
HUR 139	51	M	Caucasian	180.34	91414.5	91209.2	0.21	0.22	68337.9	67878.6	242	280	2
HUR 141	57	F	AA	167.64	65306.7	67059.5	0.33	0.34	41178.5	42054.6	145	175	2
HUR 142	62	F	Caucasian	163.83	74384.5	72809.9	0.40	*	42368.1	*	96	*	2

ID #	MV Pre (Trained)	SCF Pre (Trained)	IMF Pre (Trained)	MV After (Trained)	SCF After (Trained)	IMF After (Trained)	MV Pre (Untrained)	SCF Pre (Untrained)	IMF Pre (Untrained)	MV After (Untrained)	SCF After (Untrained)	IMF After (Untrained)
HUR 096	*	61.655	51.434	*	63.466	50.941	*	72.000	55.758	*	79.620	53.332
HUR 097	959.307	*	*	1042.613	*	*	958.746	*	*	998.505	*	*
HUR 098	1650.669	46.354	36.844	1762.658	46.872	38.391	1623.928	46.942	46.301	1601.089	44.183	52.699
HUR 099	1834.526	35.139	34.945	2119.296	36.457	36.668	1864.837	33.469	29.320	1845.041	32.748	30.762
HUR100	1476.772	31.113	51.223	1612.340	30.841	59.273	1487.400	33.416	49.078	1523.175	33.583	56.145
HUR105	903.232	96.952	24.855	1023.500	99.905	26.086	795.418	94.509	22.887	866.935	94.113	25.980
HUR 108	1604.726	99.211	68.730	1754.570	109.916	63.633	1466.452	96.759	78.504	1484.176	107.007	86.766
HUR109	1163.006	82.758	54.281	1269.026	93.401	50.238	1199.177	91.178	47.355	1216.833	94.860	42.574
HUR110	1109.804	138.894	55.652	1180.098	127.600	65.320	1092.501	125.130	52.910	1123.801	125.859	61.594
HUR112	1194.718	63.281	97.910	1238.614	71.455	112.676	1097.479	63.439	102.797	1042.369	67.175	108.316
HUR113	1682.501	18.791	41.379	1828.065	21.190	39.059	1553.319	20.188	43.348	1518.393	21.718	42.117
HUR114	900.335	119.496	58.570	1063.764	121.676	54.879	819.660	109.020	72.703	854.461	114.486	55.195
HUR115	1673.822	40.623	18.176	1862.970	42.478	9.563	1664.800	41.563	22.852	1647.674	43.040	14.730
HUR 117	1290.431	33.152	18.560	1356.081	34.128	30.160	1121.042	33.029	17.020	1113.200	34.242	27.420
HUR 118	1125.613	94.017	27.316	1226.716	96.592	26.227	1147.211	89.912	31.500	1149.146	90.923	33.293
HUR 119	1568.867	121.377	49.746	1644.936	121.667	49.289	1571.374	115.849	55.898	1554.783	114.012	52.453
HUR 121	1589.881	52.444	56.180	1709.958	51.820	58.887	1526.101	49.544	64.969	1516.694	50.546	62.367
HUR122	1664.847	103.535	31.465	1858.247	109.617	31.430	1576.475	106.884	34.242	1640.255	109.960	35.648
HUR 123	977.955	94.781	40.605	1002.487	96.442	36.809	927.189	86.405	45.211	944.960	85.808	38.426
HUR 124	1244.933	58.790	29.320	1353.916	52.488	22.080	1254.240	63.519	30.160	1242.560	55.204	22.610
HUR 126	884.058	138.234	82.793	1001.466	138.867	44.824	926.254	119.171	65.531	985.077	118.143	38.777
HUR 127	2689.282	118.116	144.281	2706.005	117.026	136.969	2408.231	122.159	131.168	2326.437	116.130	126.563
HUR 128	1083.788	41.590	19.336	1149.962	43.436	24.891	985.894	41.186	23.730	988.242	41.133	24.715
HUR 130	878.859	90.158	48.970	911.373	85.711	51.930	606.555	101.004	80.610	639.373	87.970	74.850
HUR 131	808.594	58.799	22.610	959.685	57.621	26.680	809.826	55.696	27.350	816.877	52.813	31.180
HUR 133	1504.737	117.431	62.684	1626.632	112.043	55.512	1513.917	113.229	66.129	1559.134	108.229	61.945
HUR 135	1352.597	53.244	19.793	1452.526	52.260	28.477	1435.203	53.771	18.141	1394.068	52.770	32.766
HUR 136	1027.356	272.320	86.414	1121.264	267.495	90.738	1198.897	269.754	105.645	1235.406	268.576	105.117
HUR 137	1519.084	102.621	84.375	1588.651	97.875	61.102	1660.003	106.576	74.848	1628.901	99.545	50.625
HUR 138	1262.384	98.895	50.660	1324.046	101.153	45.140	1308.670	100.635	37.970	1311.271	99.422	46.550
HUR 139	2165.347	35.710	39.480	2263.000	35.165	34.348	2154.385	34.682	38.813	2133.819	33.671	34.137
HUR 141	1494.196	61.462	59.238	1632.114	62.086	58.148	1494.262	62.666	61.348	1539.427	62.508	66.059
HUR 142	1204.780	87.188	62.965	1239.181	89.060	63.211	1025.336	88.849	52.383	1023.662	90.519	52.031

ID #	Age	Sex	Race	Height	Pre Weight	After Weight	Pre body fat %	After body fat %	Pre FFM	After FFM	Pre 1RM	After 1RM	Anti-inflammatory Drug Usage
HUR 145	56	M	AA	170.18	99695.5	100244	0.30	0.28	67027.1	69355.5	213	335	1
HUR 149	56	F	AA	162.56	69100.3	68969.1	0.35	0.34	42361.7	43560.2	108	110	2
HUR 150	56	M	AA	167.64	88588.3	89533.4	0.23	0.22	65430.9	67446.8	205	311	2
HUR 151	50	F	Caucasian	162.56	61646.4	61484.1	0.37	0.37	36641.7	36734.2	106	120	2
HUR 155	65	F	Caucasian	172.72	94170.3	94211.1	0.38	0.36	56076	58231.8	98	110	2
HUR156	61	M	Caucasian	177.8	111031	111543	0.34	0.34	70637	71110.2	236	330	2
HUR160	61	M	AA	172.72	76462.6	74951.5	0.26	0.26	53569.2	52982	150	204	2
HUR161	58	M	Caucasian	175.26	88323.6	87626.8	0.29	0.29	59380.8	59276.8	200	240	2
HUR 164	52	M	AA	178.9	66682.4	68452.8	0.22	0.21	49817.6	52281.3	160	200	2
HUR 168	67	M	Caucasian	168.8	79433.6	80114.5	0.26	0.27	56191.4	55979.3	164	180	1
HUR 169	64	F	Caucasian	157.48	56524.1	54453.2	0.37	0.38	33960.2	32308	73	95	2
HUR 171	74	M	AA	182.8	78924.9	80346.9	0.19	0.21	60938.4	60371.5	185	215	2
HUR 172	56	M	Caucasian	172.72	82605.9	81950.9	0.26	0.26	57964.6	57677.8	190	225	1
HUR 174	74	M	Caucasian	183.7	84638.3	84692.6	0.23	0.22	62736.3	63305	190	245	2
HUR 175	51	M	Caucasian	167.9	101837	102729	0.36	0.34	63089	65618.3	170	215	1
HUR 176	62	M	Other	170.7	79101.2	80285.8	0.28	0.27	54609.1	56022.5	138	168	2
HUR 182	53	M	Caucasian	179	81699.2	82249.6	0.29	0.27	55412.7	57223.2	250	300	2
HUR 183	52	F	Caucasian	162.1	82699	82520.8	0.42	0.40	45989.2	47096.7	150	150	2
HUR 184	52	F	AA	166.1	86061.7	87867.9	0.39	0.39	49609	51333.9	185	217	2
HUR 185	56	F	AA	167.6	95398	*	0.43	*	51681.9	*	107	187	1
HUR 187	60	F	Caucasian	158.3	98148.5	96916.1	0.45	0.43	51251.8	52851.2	122	140	2
HUR 188	51	M	Caucasian	177.1	119201	119349	0.34	0.34	75395.3	75720.5	265	330	1
HUR 189	62	F	Other	150.7	58800.6	59800	0.39	*	33923.3	*	65	87	2
HUR 190	55	F	AA	164.3	75741.8	76574.4	0.41	0.40	42098.1	43607.8	127	175	2
HUR 191	80	F	Caucasian	155.1	53386.4	*	0.35	*	33062.8	*	70	100	2
HUR 192	54	F	AA	165.5	81143	82375.5	0.46	0.46	41608.1	41993.5	135	168	2
HUR 198	59	M	Caucasian	177.80	104561	100157	0.30	0.30	70082	66487.8	180	200	1
HUR 201	59	F	AA	165.30	87400.8	90242.8	0.41	0.40	48927.8	51760.9	157	164	2
HUR 202	61	M	AA	176.20	90292.2	89142.7	0.28	0.29	62070.3	60990.1	255	255	2
HUR 203	53	F	Caucasian	168.50	55540.8	55870.5	0.29	0.28	37341.8	37948.7	92	143	2
HUR 204	51	F	Caucasian	155.90	107944	107863	0.52	0.53	49745.1	48559.2	125	165	2
HUR 205	50	F	AA	170.10	117985	122048	0.53	0.54	52374.7	54103.9	135	180	2
HUR 206	61	M	Caucasian	179.20	86889.6	86513.6	0.23	0.24	63785.2	63000.9	230	273	2

ID #	MV Pre (Trained)	SCF Pre (Trained)	IMF Pre (Trained)	MV After (Trained)	SCF After (Trained)	IMF After (Trained)	MV Pre (Untrained)	SCF Pre (Untrained)	IMF Pre (Untrained)	MV After (Untrained)	SCF After (Untrained)	IMF After (Untrained)
HUR145	2535.794	91.178	116.156	2997.120	81.413	107.684	2449.616	75.067	75.902	2576.837	63.642	61.313
HUR 149	1370.242	110.171	51.117	1500.686	111.305	51.715	1394.815	108.053	66.270	1397.982	101.602	72.316
HUR 150	2151.013	36.501	47.640	2477.504	39.674	54.210	2154.318	34.980	48.020	2250.781	38.347	56.140
HUR 151	1073.129	125.235	34.488	1048.023	124.479	26.086	1107.409	119.892	38.285	1032.302	115.321	27.422
HUR 155	1383.904	57.041	143.859	1454.972	53.218	135.668	1673.194	61.980	151.945	1686.687	55.125	144.176
HUR156	2366.451	86.098	68.203	2634.743	89.086	58.008	2377.607	84.577	53.895	2392.458	87.293	54.914
HUR160	1877.258	40.966	35.824	1922.196	39.480	32.168	1860.176	50.036	30.199	1817.942	44.323	27.914
HUR161	1907.006	118.837	37.512	2012.139	118.538	40.078	1945.101	130.236	35.051	1939.032	116.587	39.832
HUR 164	1567.993	40.184	44.402	1843.925	40.140	30.727	1454.206	39.129	42.469	1506.396	38.426	36.246
HUR 168	1540.693	47.259	45.633	1646.587	49.017	56.145	1480.226	49.852	44.086	1506.311	49.808	44.367
HUR 169	924.925	107.183	19.266	943.948	97.559	18.070	862.249	115.295	20.918	871.007	101.338	22.676
HUR 171	1754.243	33.987	24.012	1983.363	35.235	37.723	1756.190	35.640	24.539	1746.914	38.276	41.203
HUR 172	1928.829	43.752	36.141	2078.372	43.146	37.125	1837.187	45.431	40.008	1841.924	42.996	43.383
HUR 174	1744.847	35.789	37.266	1934.496	35.754	32.238	1874.680	36.387	42.117	1883.244	36.378	38.039
HUR 175	1862.485	85.061	67.113	2128.001	88.233	53.438	1796.953	90.677	69.855	1803.034	92.426	51.609
HUR 176	1651.687	48.955	54.105	1757.415	50.528	55.793	1574.383	48.876	53.262	1568.078	50.326	56.672
HUR 182	2035.146	36.325	37.160	2221.668	38.856	41.203	1939.508	35.033	36.598	1937.140	34.849	40.641
HUR 183	1375.949	143.323	52.734	1586.017	153.422	43.805	1436.784	141.416	54.492	1455.227	141.838	45.527
HUR 184	1663.727	124.163	113.203	1900.283	137.013	113.238	1556.343	118.125	92.707	1591.732	137.013	97.664
HUR 185	1544.672	165.472	75.480	1685.482	169.339	83.461	1641.809	160.304	76.219	1701.763	161.191	80.613
HUR 187	1389.782	121.913	81.281	1512.272	121.043	80.789	1275.786	86.625	80.613	1309.099	84.067	73.230
HUR 188	2224.278	142.356	78.152	2478.824	156.103	79.207	2161.436	137.285	82.793	2189.286	149.335	77.063
HUR 189	902.763	57.041	86.098	992.211	60.469	83.355	895.506	53.060	66.410	931.239	56.092	72.000
HUR 190	1383.799	95.933	52.664	1585.445	98.156	35.367	1404.067	83.470	47.004	1434.184	81.773	39.973
HUR 191	913.854	68.071	38.988	969.543	68.968	40.148	916.784	62.279	36.773	942.889	67.456	38.250
HUR 192	1449.365	204.205	61.805	1522.535	204.091	63.246	1365.476	192.797	76.043	1399.378	186.451	64.934
HUR 198	2036.364	54.422	56.452	2188.709	46.389	48.586	2051.978	56.496	67.887	2038.098	52.682	54.492
HUR 201	1614.920	113.704	53.719	1798.379	114.021	46.055	1667.348	114.627	56.320	1475.337	122.370	52.383
HUR 202	2020.242	53.534	103.711	2290.865	55.995	74.531	1891.045	53.183	104.063	1872.140	52.532	80.473
HUR 203	1127.545	52.989	43.945	1247.402	50.001	36.281	1108.540	49.104	50.590	1095.596	47.426	40.289
HUR 204	1244.558	276.759	73.301	1389.374	269.104	69.609	1228.949	267.601	84.445	1245.010	258.882	74.355
HUR 205	1481.441	297.404	132.047	1579.098	294.794	142.910	1456.392	286.559	164.109	1483.889	285.680	159.855
HUR 206	2069.873	65.338	40.535	2152.215	66.234	40.008	1811.374	57.085	38.988	1802.948	63.828	32.379

ID #	Age	Sex	Race	Height	Pre Weight	After Weight	Pre body fat %	After body fat %	Pre FFM	After FFM	Pre 1RM	After 1RM	Anti-inflammatory Drug Usage
HUR 207	54	F	Caucasian	164.50	50690.3	50306.2	0.32	0.35	32728.2	30859.1	67	93	2
HUR 208	54	M	Caucasian	185.10	92986	93447.7	0.26	0.25	65229.4	66421.9	275	304	2
HUR 209	68	M	Caucasian	182.20	103267	100956	0.32	0.32	66489.4	65651.7	190	222	2
HUR 210	66	F	Caucasian	160.10	92764.9	95951.4	0.48	0.47	46419.4	48443.1	87	107	1
HUR 211	62	M	AA	169.40	98953	98673.9	0.26	0.23	70678.1	72876.3	175	190	2
HUR 212	56	M	Caucasian	168.70	84389.8	84426.6	0.27	0.26	58613.1	59987.5	200	260	2
HUR 213	75	F	Caucasian	159.90	63197.5	60768.5	0.37	0.36	38026	37470.8	92	130	2
HUR 215	58	F	Caucasian	165.60	69829.2	70823.1	0.39	0.38	40809.1	41714	132	153	2
HUR 216	66	M	Caucasian	170.90	89449.5	90408.5	0.33	0.32	57157.2	58662.9	147	215	2
HUR 218	63	F	Caucasian	158.90	87891	87700	0.45	*	46229.3	*	85	121	2
HUR 220	58	F	Caucasian	161.20	61692.4	61977.3	0.40	0.40	35080	35559	100	110	2
HUR 221	77	F	Caucasian	168.20	72669.9	72010.8	0.41	0.40	40805.6	41278.1	77	85	1
HUR 222	61	F	Caucasian	165.50	86149.8	85452.8	0.45	0.44	45000.7	45330.6	82	130	2
HUR223	55	F	Caucasian	162.80	63777	65476.7	0.39	0.39	36565	37602	100	125	2
HUR224	56	M	Caucasian	176.10	*	101295	*	0.28	*	70668.4	197	240	1
HUR 225	59	F	Caucasian	152.40	67379.8	65030.9	0.33	0.32	43249.6	42003.4	115	136	2
HUR 226	73	M	Caucasian	178.10	107816	108019	0.39	0.36	63537.9	66462.8	143	178	2
HUR 227	71	M	Caucasian	165.10	80425.3	80414.5	0.27	0.29	56182.6	54247.1	162	200	1
HUR 228	78	F	AA	152.40	62628.8	62043.8	0.32	0.34	40562.9	38976.7	87	118	2
HUR 231	69	F	AA	158.20	113322	114379	0.48	0.47	56263.6	57685.7	116	135	1
HUR 232	54	M	Caucasian	189.70	111881	112915	0.27	0.30	78602.6	75999.2	270	328	2
HUR 233	73	F	Caucasian	163.10	72241.8	70161.6	0.42	0.43	39883.3	37824.2	130	130	1
HUR 234	79	M	Caucasian	169.90	84672.2	83841.9	0.29	0.31	57645.3	55280.8	146	178	1
HUR 235	55	F	Caucasian	152.20	71748.2	72207.2	0.42	0.43	39466.6	39583.8	105	135	2
HUR 236	57	M	Caucasian	163.80	105418	105259	0.34	0.34	66981.2	66832.5	204	230	1
HUR 237	51	F	Caucasian	170.90	122603	121906	0.43	0.44	66830.1	65753.6	85	108	2
HUR 238	61	M	Caucasian	184.60	78557.2	81610	0.16	0.19	62575.4	62776.8	222	250	2
HUR 239	51	M	AA	188.90	96611.2	97266.9	0.26	0.28	68131.7	66495	194	280	2
HUR 240	64	F	AA	162.40	96429.6	94804.9	0.42	0.43	53322.5	51592.9	102	126	2
HUR 242	59	M	Other	176.20	84701.7	83686.7	0.29	0.29	58037.2	56736.3	160	182	2
HUR 244	54	F	Caucasian	174.10	76255.7	79875.7	0.37	0.37	46064.3	48034.3	130	150	2
HUR 245	54	M	Caucasian	184.10	72821.6	75851.9	0.08	0.08	63125.4	65495.3	275	285	2
HUR 247	61	F	AA	165.10	77696.5	79380.8	0.41	0.40	43485.7	45207.7	130	170	2

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HUR 207	826.895	64.740	46.020	896.324	64.362	43.031	816.111	65.865	38.320	817.967	66.718	40.535
HUR 208	2208.232	45.773	35.402	2415.236	45.932	32.695	2556.464	50.660	44.648	2485.648	49.878	37.723
HUR 209	2076.843	56.417	70.031	2129.363	50.150	67.887	2153.005	64.477	81.211	2059.613	55.670	83.813
HUR 210	1105.773	130.553	72.387	1214.556	125.323	72.563	1151.571	120.190	65.918	1193.790	130.421	64.934
HUR 211	2032.078	32.194	71.121	2191.816	34.339	69.645	2067.475	33.354	79.875	2039.792	34.383	77.133
HUR 212	1914.507	42.117	48.059	2159.929	43.427	48.973	1795.761	44.947	37.441	1765.312	43.559	41.203
HUR 213	1095.383	68.572	53.684	1165.856	65.399	48.621	1019.766	68.379	48.938	1004.670	65.646	45.070
HUR 215	1216.862	105.908	36.738	1290.076	102.507	31.219	1156.516	100.345	34.980	1164.643	102.586	39.867
HUR 216	1851.776	70.857	51.398	2006.704	65.426	47.320	1812.264	71.060	49.887	1802.157	65.496	41.730
HUR 218	1326.794	111.305	63.703	1386.743	116.666	57.305	1323.712	102.709	56.988	1327.819	103.605	55.125
HUR 220	983.441	64.529	65.285	1085.122	63.439	61.559	971.592	68.827	63.809	977.075	66.419	61.523
HUR 221	975.096	78.381	75.340	1051.422	78.354	75.094	920.419	73.556	67.324	1000.469	73.046	69.152
HUR 222	1003.339	128.312	45.492	1097.710	121.254	47.180	891.380	118.433	46.723	872.445	110.171	47.672
HUR223	993.950	77.449	49.219	1093.695	78.601	47.250	888.768	84.709	45.949	899.362	87.557	47.883
HUR224	2013.642	58.676	50.590	2229.704	59.854	41.344	2120.400	65.048	38.883	2138.758	66.261	36.035
HUR 225	1279.045	89.895	32.203	1307.777	86.388	33.152	1212.408	77.739	33.609	1127.712	74.136	36.984
HUR 226	1692.110	86.502	93.551	1839.202	83.065	94.676	1555.231	90.299	91.020	1546.836	90.703	89.438
HUR 227	1641.988	47.048	56.988	1854.732	44.824	60.715	1715.395	42.425	59.098	1650.665	40.342	55.512
HUR 228	1160.466	115.427	26.719	1324.108	108.343	24.609	1118.745	111.586	28.090	1113.544	107.851	28.512
HUR 231	1287.170	256.597	208.055	1364.542	255.252	192.270	1215.479	233.104	192.023	1228.275	230.449	178.313
HUR 232	2819.979	45.923	58.500	3111.987	48.164	66.094	2795.776	46.310	52.805	2871.092	51.240	48.621
HUR 233	1005.356	115.778	63.035	1095.795	109.802	63.141	1056.107	109.011	64.160	1032.976	105.899	65.355
HUR 234	1609.303	47.865	98.824	1732.845	50.757	101.461	1520.139	47.145	93.656	1493.443	46.723	89.684
HUR 235	993.903	166.157	37.898	1070.599	178.392	31.570	894.436	173.101	35.402	912.797	177.170	33.961
HUR 236	1849.215	109.134	99.703	2013.652	109.573	103.957	1999.726	106.233	86.695	1996.394	108.861	93.938
HUR 237	1261.786	207.888	86.133	1385.692	207.211	75.375	1280.206	247.430	92.777	1280.413	257.511	90.387
HUR 238	1968.404	29.057	36.563	2094.924	29.830	32.871	1910.564	30.735	36.844	1869.773	28.037	34.031
HUR 239	2391.063	53.648	65.215	2645.497	58.491	68.203	2502.340	51.398	59.836	2578.937	53.394	57.270
HUR 240	1259.695	167.063	75.586	1407.716	169.093	71.121	1107.320	141.038	74.074	1099.835	136.749	81.141
HUR 242	1821.894	42.451	48.902	1888.492	41.344	52.453	1775.466	38.900	50.695	1776.035	38.637	52.629
HUR 244	1268.173	109.934	54.914	1379.219	118.696	53.438	1284.750	115.277	54.246	1357.773	121.966	52.805
HUR 245	2174.939	14.080	2.320	2530.641	14.748	3.305	1969.057	13.078	2.461	2292.634	13.307	2.320
HUR 247	1523.702	112.175	60.152	1683.924	126.448	57.656	1526.378	127.116	48.867	1557.500	115.207	56.848

ID #	Age	Sex	Race	Height	Pre Weight	After Weight	Pre body fat %	After body fat %	Pre FFM	After FFM	Pre 1RM	After 1RM	Anti-inflammatory Drug Usage
HUR 248	71	F	Caucasian	158.90	59882.6	59842	0.33	0.31	38081.2	39233.4	82	89	1
HUR 249	74	M	Caucasian	176.20	73026.7	70598.3	0.27	0.26	50751.2	49803.2	137	150	2
HUR 251	66	M	Caucasian	175.60	87292.8	90285.2	0.28	0.30	60369.8	60511.3	175	210	2
HUR 252	52	M	Caucasian	175.60	86438.9	88576.2	0.24	0.24	62762.2	63939	252	250	2
HUR 253	55	F	Caucasian	158.30	67992.2	67846.2	0.40	0.39	38966.9	39300.5	123	150	2
HUR 256	67	M	AA	183.90	113740	111113	0.29	0.29	77602.4	75334.7	270	295	2
HUR 258	66	F	AA	166.50	88862.1	87815.1	0.41	0.40	49836.6	50475	148	168	2
HUR 259	72	F	Caucasian	165.20	54568.7	55513.4	0.31	0.25	35582	39468.6	95	115	1
HUR 260	72	F	Caucasian	157.40	77595.9	76655.9	0.43	0.43	42392.1	41349.3	91	110	2
HUR 261	54	M	AA	191.00	106230	107713	0.31	0.31	69681.9	70288.3	280	305	2
HUR 262	52	F	AA	161.30	61564.9	61632.7	0.27	0.28	42581.4	41754.1	135	144	2
HUR 264	62	F	Caucasian	158.20	61658.1	*	0.43	*	33193.8	*	82	110	2
HUR 265	59	M	Caucasian	165.90	79241.7	80271.1	0.29	0.30	54288.8	53878.9	147	*	1
HUR 266	57	M	AA	168.20	92640.9	92710.6	0.26	0.27	65536.5	64749.7	220	250	2
HUR 268	57	F	AA	176.20	78343.4	82895.8	0.36	0.37	47442.8	49593.6	156	180	2
HUR 269	56	M	AA	171.70	106601	108258	0.31	0.29	70404.9	73540.5	240	265	2
HUR 271	64	F	Other	148.40	51172.3	50781.4	0.45	0.44	26507	26848.9	58	77	2

ID #	MV Pre (Trained)	SCF Pre (Trained)	IMF Pre (Trained)	MV After (Trained)	SCF After (Trained)	IMF After (Trained)	MV Pre (Untrained)	SCF Pre (Untrained)	IMF Pre (Untrained)	MV After (Untrained)	SCF After (Untrained)	IMF After (Untrained)
HUR 248	926.001	59.168	54.738	969.007	67.518	61.840	940.791	58.896	46.969	947.593	65.013	58.605
HUR 249	1396.125	32.669	35.578	1590.846	35.244	34.770	1434.259	32.344	37.055	1486.904	34.216	31.816
HUR 251	1710.062	58.939	47.461	1916.784	67.975	53.402	1581.494	64.345	42.258	1635.961	69.152	40.816
HUR 252	1992.571	44.016	38.672	2315.179	48.234	41.941	1835.227	42.935	33.398	1889.872	45.730	35.859
HUR 253	1071.932	61.040	37.371	1163.869	66.674	40.852	1053.005	60.311	33.820	999.430	64.969	41.133
HUR 256	2562.836	103.140	67.465	2744.085	99.264	65.496	2372.124	92.461	67.465	2152.828	89.227	57.586
HUR 258	1418.611	136.046	89.297	1507.467	130.008	85.465	1513.637	137.558	81.176	1528.265	137.171	79.488
HUR 259	1053.105	69.847	28.090	1198.057	69.627	25.559	817.308	77.915	29.039	842.909	77.889	31.008
HUR 260	1001.686	117.747	88.313	1098.658	108.193	79.594	956.525	116.455	82.723	941.395	113.977	76.219
HUR 261	2599.845	69.047	90.316	2839.187	72.870	85.043	2661.283	76.632	86.730	2644.229	75.428	83.848
HUR 262	1432.221	62.657	61.453	1515.140	59.862	59.871	1351.246	68.370	63.949	1332.989	68.440	66.305
HUR 264	881.993	117.439	45.633	1002.027	111.349	42.223	893.199	113.388	41.238	880.854	106.699	35.402
HUR 265	1310.808	36.000	41.801	1549.971	41.695	43.418	1281.560	36.378	42.434	1318.211	40.315	37.230
HUR 266	2206.293	83.549	92.813	2476.982	82.978	87.188	2112.808	84.076	98.227	2302.095	82.230	90.176
HUR 268	1725.697	104.546	89.543	1881.295	108.773	104.484	1676.032	103.878	87.047	1695.555	107.490	88.770
HUR 269	2679.999	81.958	57.902	2848.765	85.395	60.680	2570.293	85.122	54.879	2679.999	83.285	54.422
HUR 271	703.060	121.896	35.156	797.512	116.604	36.035	718.049	118.529	32.801	729.072	118.310	30.938

APPENDIX D: LITERATURE REVIEW

The following review of literature is divided into the effects of age on regional body composition, the effects of sex and race on regional body composition, and the effects of strength training (ST) on regional body composition. Across these three areas the review will focus on the following topics: 1) the importance of skeletal muscle mass and strength to health and function, 2) the importance of regional body fat depots to health and function, 3) imaging techniques for the assessment of regional body composition, 4) the influence that sex and race effects on regional body composition has on health status, and functional abilities, 5) the effect of ST on total and regional body composition, 6) the effect of sex and race on ST-induced changes in regional body composition, and 7) the possible mechanisms for the ST-induced changes in regional body composition.

Importance of Skeletal Muscle Mass and Strength to Health and Function

The age-associated loss of skeletal muscle mass was termed sarcopenia in 1989 by Irwin Rosenberg (55). Approximately nine million persons in this country have a muscle mass less than two standard deviations below the sex-specific means of reference data for young adults (112). Reductions in skeletal muscle mass relative to body weight can start as early as the third decade (54). Limb muscle mass is significantly reduced after the age of 60 (70; 73) causing 64.3% of men and 31.3% of women to develop some form of sarcopenia after this age (56). Appendicular skeletal muscle is of vast importance because it accounts for more than 75% of total body skeletal muscle (31) and proper function is necessary in ambulation.

The loss of muscle mass above normal rates, especially in the lower limbs, is debilitating for the aging community. Without the ability to carry out their activities of daily living, the process of sarcopenia compounds itself, eventually immobilizing individuals. It is a major health care burden, as evidenced by an estimated $18.5 billion, or roughly 1.5% of total direct health care costs in this country attributed to sarcopenia in 2000 (56). Visser et al. (143; 144) extensively studied the relationship between muscle mass and function through the Health, Aging and Body Composition study. Both baseline (144) and prospective (143) data from this group demonstrates that lower muscle mass (smaller mid-thigh CSA measured through CT) is associated with increased risk of mobility loss in large groups of older AA and Caucasian men and women. Mobility loss was defined as either a self-reported difficulty in walking one-quarter of a mile or climbing 10 stairs (143), or a poor combined score in the usual pace timed gait test and five chair stands test (144).

In a large group of multi-ethnic men and women aged 60 and above from the Third National Health and Nutrition Examination Survey (NHANES III), functional impairment was ~two times greater in older men and three times greater in older women with severe sarcopenia compared to their peers with normal muscle mass (53). Severe sarcopenia (class II) was defined as a skeletal muscle mass index (skeletal muscle mass/body mass x 100) less than two standard deviations below a reference group aged 18-39 yrs. Functional impairment was classified as having limitations in mobility performance (i.e., walking, climbing stairs). Furthermore, a population-based cross-sectional study surveyed 808 elderly adults in New Mexico in an effort to determine whether there are any associations between sarcopenia and health

behaviors, chronic morbidity, physical function impairment, disability, and falls. Sarcopenic individuals had a relative loss in muscle mass, defined as values two standard deviations below the sex-specific means of reference data acquired from a subset of young adults (31). Results indicated that low relative muscle mass was associated with functional impairment and disability measured through self-reported activities of daily living (8). This relationship was independent of age, ethnicity, obesity, socioeconomic status, morbidity, and health behaviors. The debilitating affects of sarcopenia are made all the more evident by Janssen et al. (56) who calculated population attributable risk in 2000 in order to determine the effects of sarcopenia on disability. The authors suggested that 85.6% of the disability cases in older men (≥60 yrs) and 26.0% of the disability cases in older women (≥60 yrs) were related to sarcopenia (56).

The association between low muscle mass and functional decline seems to be effected by underlying muscle strength (143). Sarcopenia is associated with a loss of muscle strength (22; 24; 37; 70; 88) which begins sometime after the 40s (60; 73) at a rate of ~8-10% per decade (70). The time frame of changes in anatomy and strength are similar as Hughes et al. (47) found isokinetic strength in the knee flexors and extensors declines slightly more than 1% per year. To determine the relationship between skeletal muscle mass and strength, observations were taken at baseline and after roughly 10 years in a group of 120 men and women between the ages of 46 and 78 years of age.

A loss of strength in a multitude of muscle groups and populations has shown to affect activities of daily living during the aging process. A decline in grip strength,

which has shown to accelerate past the age of 40 (60), also predicted functional limitations and disability in a large cohort of Japanese-American men living in Oaho, Hawaii (102). Meanwhile, limited data suggests sarcopenia is most extensive in the lower extremities (31; 54) further exemplifying how this condition affects function. Knee extensor strength in women as measured by a hand-held dynamometer, as well as balance, is associated with severe walking disability (100) and the risk of developing such a condition three years after being functional (101). Furthermore, the relative risk of acquiring a disability in the group with poorest strength and balance adjusted for age, height, weight, and race was more than five times that of the reference group (101).

Decline in muscle mass and strength during the aging process is not only related to a decrease in function and quality of life, but most importantly this condition is associated with early death. Since length of life is the best overall indicator of population health, variables that predict mortality are intuitively critical. Mobility loses are significantly related to risk of death in older adults above the age of 75 (66). As mentioned previously, muscle mass and strength are highly related to mobility loss, but there is also evidence to suggest that these variables are directly associated with mortality. For example, Metter et al. (79) followed 1071 men over 25 years to examine the affects of muscle mass and strength on mortality. Surviving men who were less than 60 years of age at baseline had a greater initial muscle mass (measured through creatine excretion values) and quicker rate of change in muscle strength (determined through isometric grip strength), but did not differ in baseline grip strength compared to those not still alive from the same age group. In men older than

60 at baseline, the main difference between survivors and those deceased was muscle strength. Baseline grip strength was also predictive of mortality in groups of 45-68 year old Hawaiian men (104) and 40-84 year old Japanese men (26).

Even though skeletal muscle mass correlates with muscle strength, sarcopenia can not explain the entire influence muscle strength decline has on mortality. In this regard, Newman et al. (89) showed that isokinetic quadriceps and isometric forearm strength are strong predictors of all-cause mortality independent of CT measured mid-thigh CSA. Because low muscle mass did not explain the association of strength with mortality, this study demonstrated that strength as an indicator of MQ is more important than muscle mass in estimating potential for early death.

Importance of Regional Body Fat Depots to Health and Function

In addition to the exaggerated skeletal muscle mass loss seen in many adults, composition of the tissue in and around the muscle also changes with aging. Certain regional components are most affected by the aging process, namely fat accumulation within muscle fibers (intramuscular fat), outside of the muscle fibers and between bundles (IMF), as well as fat underneath the skin and outside of the muscle fascia (SCF). Intramuscular fat increases with age as seen through MRI (141) and muscle biopsy (20). Recently, studies have examined regional body composition using imaging techniques which allow determination of muscle density through attenuation values (38). Low muscle attenuation values are an indicator of decreased muscle density and an increased muscle fat infiltration. Goodpaster et al. (37) presented results from The Health ABC Study of 2,627 multi-racial men and women (70-79 yr), showing mid-thigh muscle density decreased with age and is negatively associated

with BMI. Aging was also associated with IMF as healthy AA women over 65 years presented a significant full body increase in this lipid depot over a two year span free of intervention (128). Meanwhile, SCF has been shown to increase with age in the abdominal areas of women (113), the arms of men (106), and the legs of men (95).

Muscle fat infiltration, similar to muscle mass, has been associated with increased risk of mobility loss in older AA and Caucasian men and women (143; 144). Data indicated men and women with the highest muscle attenuation values had the highest MQ (37), suggesting that muscle density is associated with muscle strength. Thus, due to previously mentioned data showing the association with mobility loss and mortality, these indicators of regional body composition, along with muscle mass, should be considered in disability prevention programs.

High levels of regional body fat can also lead to insulin resistance and eventually type 2 diabetes mellitus. Several studies have presented an association between skeletal muscle lipid content and insulin resistance by using a variety of methods to measure skeletal muscle lipid content. For instance, Goodpaster et al. (39) used CT imaging to show the association of mid-thigh IMF and low muscle density to insulin resistance in separate groups of lean, obese, and type 2 diabetic men and women of middle age. However, the same group of subjects did not present the association with mid-thigh SCF, which comprised nearly 90% of total thigh adipose tissue (39). Low density muscle is another correlate of insulin resistance in obese middle-aged men and women (40). Using CT imaging, Goodpaster et al. (40) presented a negative correlation between insulin sensitivity and SCF in the abdominal

region in the entire group of lean and obese (BMI = 19.6-41.0 kg/m^2) men and women.

Few studies have examined the relationship between insulin resistance and regional body composition in older subjects. One study did show a significant inverse correlation between insulin resistance and long-chain acyl-CoA esters from the vastus medialis (determined by muscle biopsy) in men (55-75 yr) who were candidates for knee replacement (27). Long-chain acyl-CoA esters are intermediates in lipid biosynthesis and fatty acid oxidation (16), and thus markers of fat accumulation.

Other deleterious effects of regional body fat include the association between mid-thigh low density muscle and total cholesterol and low-density lipoprotein cholesterol levels (113). However, this relationship, shown in women of various age groups, was not independent of total body fat and age. Thigh girth has also been suggested to be used as an indicator of cardiovascular disease risk factors in epidemiological studies because of the association between changes in mass, which is mostly SCF (39), to risk factor changes (123).

Nevertheless, deposition of fat in the lower body has been shown to be protective for certain health afflictions. The Hoorn Study, a population-based cohort study of glucose tolerance among a large sample of white men and women aged 50-75, presented the majority of data on this topic. Thigh circumference in women, but not men, was strongly and positively associated with good glucose tolerance, independent of waist circumference, which itself was associated with poor glucose metabolism (126). Because the majority of fat in the legs is stored as SCF (39), thigh circumference would be a good indicator of this fat deposition, especially in older

adults of low activity levels. In turn, preferential accumulation of lower body fat indicated through thigh (only statistically significant in women) and hip circumference (both men and women) is associated with lower relative risk of type 2 diabetes. Meanwhile, larger waist circumference is associated with a higher incidence of this metabolic disease six years following baseline examination (124). Due to such results, this study suggested that the waist:thigh ratio and waist:hip ratio are better predictors of type 2 diabetes than is overall obesity, as estimated by BMI.

DXA was performed on later cohorts in the Hoorn Study to determine fat and lean soft-tissue mass in the trunk and legs in order to confirm the previous associations between regional body composition and metabolic markers. In accordance, regression analysis showed larger leg fat was protective against a disturbed glucose metabolism, indicated by a 75-g oral glucose tolerance test (125). This association was particularly strong in women, whereas men had an additional protective effect through larger lean mass in the leg. Larger leg fat mass was also associated with lower peripheral arterial stiffness in Hoorn Study participants (127), providing evidence for a protective effect against not only metabolic diseases, but also cardiovascular diseases. Hoorn Study results, in addition to data from Japanese subjects (132), tend to suggest that fat deposition in the lower body is protective for women against diseases, especially those of metabolic nature. According to previous data showing women have relatively high lipoprotein lipase activity and low rates of basal and stimulated lipolysis in their lower body fat mass (105), accumulation of fat in the thigh could protect the liver and muscle from over exposure to free fatty acids through uptake and storage (124). However, it is important to note that this association may not be independent of

abdominal fat deposition. Postmenopausal women with an average age of 60 showed a favorable association of leg fat mass with CVD risk factors, including insulin resistance markers (142). Yet all associations were absent after adjusting for abdominal SCF, and except for serum triglycerides, absent after adjustment for abdominal visceral adiposity.

Imaging Techniques for the Assessment of Regional Body Composition

Methods used to quantify MV and fat deposition in regional body compartments range in cost, availability, practicality, and desired accuracy. Some methods can be used to measure body composition on both a full body and regional level, whereas others are relegated to one or the other. The most accurate techniques for measuring MV are the imaging methods, CT and MRI (55). CSA measurements of adipose tissue-free skeletal muscle were not significantly different than cadaver samples, as correlations derived from regression analyses ranged from 0.98 to 0.99 for both MRI and CT (81), thus validating the accuracy of these imaging methods. Specialized computer programs can quantify volume (cm^3) after taking multiple transverse cross-sectional images of muscle anywhere in the body. Although the imaging methods are accurate, reliable, and non-invasive, there are a few disadvantages. Both are expensive and the data analysis is very time consuming. There is also a small danger in terms of radiation exposure for CT.

Other indicators of muscle mass include creatinine, 3-methylhistidine, total body nitrogen and/or potassium, and DXA (55). The metabolite markers creatinine and 3-methylhistidine can be used to indicate full body skeletal muscle as daily urinary excretion is related to the skeletal muscle protein pool. However, this method,

like the total body potassium–total body nitrogen model, can not be used to quantify regional muscle area or volume. Also, reliability for the creatinine (147) and 3-methylhistidine (146) method is less than optimal, and the total body potassium-to-total body nitrogen ratio has been shown to underestimate muscle mass in healthy men compared to CT (148). In contrast, DXA can distinguish between body regions in determining MV and is highly correlated with multislice thigh muscle areas assessed by CT ($r^2 = 0.96$) in middle-aged men and women (69). DXA can also be used as a three compartment model of body composition because it measures fat-tissue mass, lean-tissue mass, and total-body bone mineral. DXA measurement of total body fat, identical to that used in the present study, compared favorably with a four-compartment model (body density, total body water, total bone mineral mass, and body weight), as well as with multislice CT scans in elderly adults (113).

Biopsy samples have long been used to measure intramuscular fat (55). However, this is an invasive procedure and is highly variable within subjects (149). In contrast, muscle lipid content and muscle density can be estimated through the noninvasive procedure of CT (55). Cross-sectional images of CT produce pixels of various intensity, displaying attenuation characteristics which are a function of tissue density and chemical composition (38). Mid-thigh muscle attenuation is associated with muscle lipid content as quantified through muscle biopsy of the vastus lateralis (38). Attenuation values are displayed in HU and are based upon a linear scale using water as the reference (0 HU) (38). The intensity value of a pixel containing adipose tissue is lower than that of one with lean mass because lipid has a lower density than water and protein. Pixels with a HU of -190 to -30 are identified as intermuscular

adipose tissue (39; 61), whereas, those ranging from 0 to 100 are considered muscle. Muscle can be further separated based upon intensity where tissue with a HU of 0 to 30 is considered low density and that 31 to 100 is high density.

SCF of the mid-thigh can also be estimated by CT (39; 40). To validate the use of CT in measuring the regional body compartments IMF and SCF, this imaging technique was compared to cadaver samples (81). Appendicular IMF and SCF areas estimated by CT were highly correlated with corresponding cadaver values ($r = 0.96$ and $r = 0.97$ respectively). Thus, although CT is incapable of directly measuring regional body composition on the basis of attenuation values (135), this technique does accurately estimate mid-thigh muscle lipid content, IMF, and SCF.

Effect of Sex and Race on Regional Body Composition, Health, and Function

From a cross-sectional perspective, an individual's sex and/or race can be a major determinant on regional body composition, and in turn health and function. Men of various ages have presented greater lower body skeletal muscle mass measured through MRI (54) and DXA (31; 73) even after controlling for height and body mass. In a comparison of older adults (average age > 70 yr) men had a greater absolute muscle CSA of the thigh measured by CT (24). For this reason, hormone replacement therapy (HRT) has become a suggested preventative measure against age-related loses in lean tissue in postmenopausal women (133). Younger men also presented a higher absolute muscle mass measured by DXA (92) but it is suggested that there is a greater reduction in magnitude with aging in this sex group (31), which could be masked by a concurrent increase in total body fat mass (30).

In contrast, women tend to carry more relative muscle mass in the legs than men (31; 54). The sex-related variance of muscle mass is important because it tends to determine the large differences in absolute strength between men and women (22). Strength differences could also be partially due to variations in hormonal levels or a greater percentage of type II muscle fibers in young and old men (62).

Muscle mass, as mentioned previously, is positively associated with mobility loss and increased mortality. Lower muscle area in the thigh is associated with poorer lower extremity performance in both men and women (143; 144). Moreover, in accordance with their lower muscle mass, older women have reported greater disability and functional limitations (77; 143), as well as scored lower in observable performance tasks (94). This sex difference in function also tends to increase with age (94). Interestingly, when following a large group of multi-racial older men and women over six years, quadriceps strength was strongly related to mortality in both sexes but lower muscle area measured by CT was an independent predictor of mortality only in men (89).

Although racial differences in regional body composition have not been studied to the same extent as sex differences, there is still enough cross-sectional evidence of differences between Caucasians and AA to justify the analysis of race as an independent variable in the current project. DXA analysis of 148 women (80 AA and 68 Caucasian) and 136 men (72 AA and 64 Caucasian) showed AA subjects had greater leg skeletal mass than Caucasians after adjusting for height, body weight, and age (31). Also, mid-thigh muscle area determined with CT was significantly greater in a large cohort of older AA men and women (37; 144).

Separate studies have confirmed that AA women have a higher skeletal mass (32), which is likely related to a greater age-related decline in Caucasians (3). This difference might be why older AA women have greater grip and hip flexor strength than Caucasians of equal levels of disability and physical activity (103). Another possible explanation for strength differences between races is that young AA sedentary men have a greater proportional area of type IIa muscle fibers than age, height, body weight, and BMI matched Caucasians (6). Type IIa fast twitch muscle fibers are known to have a greater force capacity than type I fibers as mostly seen in men (24), and decline at a greater rate with aging (134) than slow twitch fibers. There is currently no reason to suspect sex affects the discrepancy in fiber type composition between races differently in women than men. However, muscle mass and strength do not appear to be the underlying cause of disability and mortality between races. This is because separate studies have reported a greater self-described difficulty in lower body tasks (93), poorer scores in lower extremity performance tests (144), and ~25-30% higher mortality rates in AA men and women (89), despite the established advantage in muscle mass and strength.

Similar to muscle mass and strength, there are differences in total body and regional fat deposition between men and women. It has been well established that sedentary women have a greater percentage of body fat than men in a variety of age groups (51; 92; 110; 150), that may not change (133) or even increase with the use of HRT in postmenopausal women (5). In addition, a limited number of studies show a greater propensity for fat deposition in the extremities of women. Total regional body fat percentage in the arms and legs was higher in younger women than age matched

men (92). Middle-aged women (<60 yr) have shown greater muscle fat content through muscle biopsy (20) and with CT, more mid-thigh SCF than men, but similar amounts of IMF (39). Elderly women (70-79 yr) also had higher mid-thigh SCF (37; 89) in addition to lower mean mid-thigh attenuation values (37). Similarly aged women displayed the same absolute amount of IMF as men, but a lower relative amount compared to total thigh adipose tissue (37), which was predominantly composed of SCF. The previously mentioned studies relating regional body fat deposition to mobility loses (143; 144), provides additional rationale for why women perform worse on functional tasks than their male counterparts (77; 94; 143), similar to the sex differences in strength and muscle mass.

Race has also been shown to affect total body fat and adipose tissue distribution. Young adult AA men had lower % body fat while similarly aged AA women had a higher % body fat compared to Caucasian peers (118). Caucasian middle-aged men and women demonstrated through MRI a roughly one kg greater amount of total adipose tissue after adjusting for sex, age, height, and weight (29). Total body carbon analysis also showed Caucasian premenopausal women had a significantly higher total body fat mass than AA premenopausal women (4).

A review of relevant literature on racial differences in regional body fat composition indicates that AA deposit relatively less SCF in the extremities than Caucasians (145). However, this review used data acquired primarily through skinfold thickness, waist:hip ratio, and DXA scans, while failing to include analysis from imaging techniques which allow for a more direct measurement of fat patterning. In this regard, Goodpaster et al. studied a large group of healthy functional men and

women aged 70-79 yr (37), and showed with CT that AA had higher absolute amounts of thigh SCF and IMF than Caucasians, with a relative difference only remaining for SCF. Furthermore, with increasing adiposity, AA men and women had significantly greater MRI derived IMF per kg of total adipose tissue independent of height, weight, and skeletal muscle mass (29). CT analysis also demonstrated AA obese (114) and non-obese (37) postmenopausal women had lower mean mid-thigh muscle attenuation values. This could possibly explain why older AA men and women had poorer lower body extremity performance, as higher muscle attenuation was associated with better function independent of mid-thigh muscle (144). Thus, imaging techniques suggest AA have higher amounts of localized fat in the lower body than Caucasians. This could be an important consideration when further examining higher mortality rates in AA (89) and other health related variables including diabetes, because AA middle-aged women matched for age, obesity level, and waist:hip ratio are more insulin-resistant than Caucasian women (71).

Racial differences in metabolic predictors of obesity could also partially explain the variation in regional fat composition between AA and Caucasians. This data could provide a rationale for hypotheses on racial influences on the effects of ST on regional body composition as there is a shortage of ST studies comparing AA and Caucasians. In 164 healthy older adults (>55 yr), total daily energy expenditure was measured through the doubly labeled water technique and indirect calorimetry was used to establish resting RMR (12). After adjustment for fat-free mass, total daily energy expenditure was 10% lower in AA compared to Caucasians due to a 5% lower resting metabolic rate and a 19% lower physical activity (PA) energy expenditure (12).

PA was determined from the following equation: PA energy expenditure (kcal/day) = (0.9 daily energy expenditure) – RMR. Additionally, RMR was shown to be 12% lower in AA premenopausal (19) and 5% lower in AA postmenopausal (91) obese women after adjustment for lean mass. In a combined group of 28-40 yr old men and women, RMR was also significantly lower in AA than Caucasians (118). These discrepancies between races could be due in part to a smaller mass of metabolically active organs (i.e. liver, kidney, heart, brain) in AA middle-aged men and women, as Gallagher et al. (28) reported statistical consideration of total organ mass reduced racial differences in RMR by over 50%. In addition, fat oxidation determined by indirect calorimetry was 17% lower in AA postmenopausal women (91). Due to this data, AA may have a greater predisposition for obesity and large fat accumulation in the lower extremities due to their lower energy expenditure, smaller organ mass, and inferior fat oxidation compared to Caucasians.

Effect of ST on Total and Regional Body Composition

With the continued rise of obesity and sarcopenia in the US, physical activity has become increasingly important for the prevention and treatment of such conditions. Current data from the Centers for Disease Control and Prevention suggests less than 50% of Americans participate in physical activity with Caucasians more active than AA. While older adults are most in need of such lifestyle, this group participates in limited physical activity as 42% of those 45-64 yr do nothing, with this value increasing with age (82). Physical activity is critical for older adults because it may have an independent impact on strength, disability, and mortality (79). Not only is the quantity of physical activity important, but so is the type. Planned exercise,

especially one which focuses on increasing strength, could help prevent the onset of disability (101). ST can improve function and health status in older adults through an increase in muscle mass, strength, quality, or bone density. Additionally, ST-related changes in regional body composition can affect obesity-related diseases. In postmenopausal type 2 diabetic women, a combined ST and aerobic training program most effectively enhanced insulin sensitivity and improved muscle characteristic compared to controls and those subjects who only trained aerobically (14). Thus, ST has become the intervention of choice for the prevention and treatment of sarcopenia and its related consequences (49; 109).

ST has been repeatedly shown to increase total body and regional muscle mass in a variety of populations. Six months of full body ST in young and older men and women increased FFM, as well as thigh and quadriceps MV, measured with MRI (110). Increases in upper and lower body strength were also evident in the study groups, demonstrating the positive influence of ST on muscle function. The significant increases observed in such variables were not different between groups, suggesting men and women of all ages have the ability to improve muscle mass and strength with ST. Results from Hunter et al. (48), Campbell et al. (11), and Binder et al. (9) confirmed that ST can induce significant increases in FFM among older adults. However, to more closely associate ST with a localized change in regional body composition, the exercise stimulus needs to be relegated to the area of examination. Regional ST produced localized muscle hypertrophy in the thigh musculature in older men (23) and women (122) following 12 and 18 weeks respectively, of lower body ST.

ST has been shown to effectively increase energy requirements, decrease total body fat mass, and maintain metabolically active tissue in older men and women (11). Thus, this mode of exercise has been suggested to be beneficial in weight-control programs for older adults (11). An improved body composition can be demonstrated through decreased body fat. Mixed results have been presented on the ST effect on % body fat, which could be due to differences in training protocol. Nichols et al. (90) reported a significant decrease in % body fat following full body ST (90), however Treuth et al. (138) showed no change as subjects lifted with a slightly less percentage of their 1RM (67% vs. 80%) in the later protocol. Lemmer et al. (68) presented a slight change ($P = 0.051$) in % body fat, but only in older men following full body ST, yet Roth et al. (110) showed no change in older men and women as a result of a similar protocol.

There is a limited amount of evidence for a ST affect on regional fat composition. Ross and coworkers concluded that ST is as effective as aerobic training in reducing regional fat stores after demonstrating SCF measured by MRI decreased in upper and lower body compartments similarly between training modalities when combined with a controlled diet (107; 108). Furthermore, Treuth et al. reported older men (140) and women (138) decreased localized fat following separate full body ST programs. While the men were analyzed with DXA, CT was performed on women to more precisely determine changes in localized fat. The women in this aforementioned study decreased intra-abdominal adipose tissue as well as mid-thigh SCF (138). However, as mentioned previously, only low correlations can be made between localized changes in regional body composition and full body ST. One such study

which attempted to isolate the ST affect through unilateral isokinetic training of the lower body in middle-aged women, found a decrease in SCF thickness in the exercising leg only, measured by ultrasound and skinfold calipers (64). Regional body composition changes are not suggested to be affected by HRT in postmenopausal women as quadriceps skeletal muscle attenuation increased similarly with and without the drug following high-impact training for the lower limbs, as well as with the drug and without exercise (131). Additional studies focusing on change in regional fat deposition following a ST program compared men vs. women and will be detailed in the following section.

Effect of Sex and Race on ST Induced Changes in Regional Body Composition

While ST has been shown to elicit significant increases in muscle mass in various age groups of men and women independently, few studies have directly compared men and women of advancing age, and none have done so with AA and Caucasians. ST programs, specifically in the lower body, for middle-aged and older subjects have inconsistently promoted muscle hypertrophy. While Joseph et al. (57) presented an increase in FFM only in 54-71 yr old men after a 12 week ST program, Hakkinen et al. (44) exhibited a larger CSA increase in the quadriceps femoris for 36-75 yr old female subjects compared to men of the same age after 6 months of heavy resistance training combined with explosive lower-body exercises. Conversely, several studies failed to show a sex-related difference in ST-induced CSA change. In two different studies, one having subjects ST with a full body protocol, including knee extension (45), and the other combining heavy full body ST along with explosive lower body exercises, Hakkinen et al. (43) showed an increase in quadriceps femoris

CSA in middle-aged and older men and women alike. Furthermore, according to McCartney et al. (76) the relative (%) increase in quadriceps CSA was similar in older men and women following 10 months of progressive ST. While HRT has been used to, among other reasons, counteract the loss of muscle mass in postmenopausal women, there seems to be no additive effect when combined with ST (10; 17; 133).

Unlike the present study, these previous results failed to evaluate the volume of the entire trained muscle group as a means of making sex comparisons. Muscle hypertrophy has been shown to vary depending on the muscle region examined (87), thus measures of volume are recommended (69) to be used instead of CSA in analysis of whole muscle growth following ST. Accordingly, several different images of the musculature must be taken in order to calculate MV. In doing so, Roth et al. (110) used MRI to show sex did not influence the change in whole thigh and quadriceps MV following full body ST.

Regional changes in muscle mass following ST can be more closely examined with the use of localized training. In addition, single leg ST allows for the control of several different within subject factors. Thus, the use of single leg KE has become a popular protocol (50; 51; 136) for the analysis of quadriceps MV changes following ST. These studies, consistent with the present study, trained the knee extensors of the dominant leg three times per week for approximately nine weeks while the untrained leg was kept in a relaxed position. A Keiser K-300 air powered knee extensor machine, which allowed for an easy change of resistance within each set, was utilized by all studies including the present one. Each of these previous studies scanned both the trained and untrained legs with MRI and used the difference in MV to quantify the

dependent variable. Older men and women were utilized as subjects in all three studies, while both studies from Ivey and coworkers (50; 51) also had young men and women participate. Ivey et al. (50) reported a significant difference ($P < .01$) in the MV response to training between men and women in the young age group, and a difference approaching significance ($P = .057$) between sexes in the older group, with men having a larger absolute increase in both age groups. There was also a significant difference ($P < .01$) between sexes when both groups were pooled, as the men's MV was 104 cm^3 greater than the women's following ST (50). Using a comparable subject pool, Ivey et al. (51) demonstrated a significant increase ($P < .01$) in absolute quadriceps MV for all four groups (young men and women, older men and women) with ST. Sex comparisons in that particular study were not made. ST increased trained leg quadriceps MV to a greater degree than the untrained leg in both sexes according to Tracy et al. (136), and similar to Ivey et al. (50), the absolute difference following training was significantly ($P < .05$) higher in older men versus older women. However, both sexes increased relative MV in the trained leg by 12% (136). Thus, unilateral ST data on the knee extensors would suggest that men increase MV to a greater extent in absolute terms with ST, while relative changes are similar to those of women.

The effect of ST on regional body fat distribution has only been studied to a limited degree. Hunter et al. (48) analyzed different fat compartments within the abdominal area with CT in a group of men and women aged 61-77 yr. Despite similar decreases in total body fat mass following 25 weeks of ST, women lost significantly more intra-abdominal adipose tissue area (-15 vs. +9 cm^2), as well as abdominal SCF

area (-15 cm^2 vs. no change) (48). Binder et al. (9) found no significant ST-related changes in intra-abdominal adipose tissue or abdominal SCF when assessed by MRI in men and women. In that study, 91 community-dwelling sedentary elderly (=/> 78 yr) men and women committed to a nine month exercise program which featured an extensive progressive ST phase (9). Finally, a recently submitted manuscript from our group used a ST protocol similar to that mentioned above (50; 51; 136), and identical to the one used in the present study, to examine the affects of ST on thigh IMF. Using a groups of sedentary middle-aged and older adults (50-83 yr) Yao et al. (150) demonstrated only genotype influenced change in IMF, as the group as a whole did not significantly change. Yao et al. did not statistically analyze sex-based main effects.

To the authors' knowledge, at the present time there have been no longitudinal studies comparing AA to Caucasians for influence on ST effects on regional body composition. Thus, inferences on the effect of race on ST related changes can only be made from cross-sectional studies, further adding to the importance of the present study.

Mechanisms for the ST Induced Changes in Regional Body Composition

Compelling evidence suggests older adults, while most susceptible to sarcopenia, still undergo substantial muscle size increases in response to intensive ST (23; 122; 136) at a similar rate as younger individuals (50; 51; 110). According to a review on the morphological adaptations to ST by Folland and Williams, the primary adaptation to this exercise modality is an increase in the CSA of skeletal muscle fibers (18). Muscle biopsy, which is necessary to analyze the changes in fiber CSA, has

demonstrated a 16% increase in single muscle fiber CSA of the vastus lateralis following 14 weeks of ST, which was correlated with changes in lower body maximal contractile strength (1). This increase in fiber CSA due to repetitive loading is suggested to be caused by growth around the periphery of existing myofibrils in the form of new proteins (84), and an increase in myofibril number (proliferation) (74). During the life-span of a mammal, myofibrils within a single muscle fiber may proliferate by as much as 10-15 times (34). The mechanism proposed by Goldspink and colleagues (34-36) involves a longitudinal splitting of Z disks within the myofibrils due to a difference in the arrays formed at the A and I bands. During muscle contraction, this array discrepancy causes actin filaments to obliquely pull on the center of the Z disks causing them to rip longitudinally (35). This action is associated with myofibrillar proliferation and muscle hypertrophy as splitting myofibrils are about twice the size of non-splitting myofibrils (34).

Along with the increase in myofibrils there is an increase in myonuclei number, which is directly correlated with muscle fiber diameter (65), and thus muscle size. Since nuclei within muscle fibers are postmitotic (121), the source of new myonuclei must come from outside of the muscle fiber (117). This source is in the form of satellite cells, which are mononucleated and located between the sarcolemma and the basil lamina of muscle fibers (75). As seen in animals cells, an increase in original muscle cell nuclei by way of satellite cells can promote muscle fiber hypertrophy (85; 86). Satellite cells repair injured myofibers, of which ST promotes, by serving as the source of myoblasts that participate in the regeneration response (117). Further adding to the significance of new myonuclei in compensatory

hypertrophy is evidence of a reduction in satellite cell proliferation following ionizing irradiation in rats during muscle loading (2), and an association between mouse soleus atrophy and a decrease in myonuclei number, of which is restored after two recovery weeks (80). Thus, satellite cell mitotic activity substantially contributes to muscle hypertrophy following functional demands, and atrophy caused by reduced physical activity (117).

Resistance exercise studies with human subjects have confirmed that an increase in satellite cell activity could represent an important mechanism to sustain muscle fiber hypertrophy. However, the association with added myonuclei is not as strong in humans as it is in animals. After a single bout of unilateral high intensity eccentric exercise in the lower body, satellite cells of the vastus lateralis increased as evident by positive staining for N-CAM, an abundant protein on the surface of early embryonic myotubes, only in the trained leg (13). While satellite cells increased, this exercise protocol did not promote muscle fiber necrosis in the human subjects (13), although in animals eccentric contractions have been suggested to promote a disruption to the proteins of myofibers that maintain cellular integrity, thus triggering a release of growth factor (21). Using a ST protocol similar to the present study, Roth et al. (111) reported an increase in satellite cell proportion in sedentary young and older men and women, further establishing this as a mechanism of muscle hypertrophy. Kadi et al. also demonstrated that full body ST will augment satellite cell proliferation in young men (58) and women (59). This increase in satellite cell quantity was correlated to an increase in myonuclear number in women (59), yet men

did not present a similar addition of myonuclei (58), indicating that humans could be able to support a certain level of muscle fiber hypertrophy with existing myonuclei.

Testosterone, a steroid hormone from the androgen group, is associated with muscle fiber hypertrophy in both young and old men (119; 120). Since greater androgen levels are commonly found in men compared to women (18), testosterone could be responsible for the larger absolute gains seen in male MV following ST (50; 51; 136). Furthermore, testosterone-induced muscle fiber hypertrophy is associated with increases in the numbers of myonuclei and satellite cells (121). Although the mechanism behind the testosterone related increase in muscle satellite cell number is unknown, this hormone must be considered as a potential mechanism for muscle hypertrophy.

While ST is predominantly prescribed for the goals of increasing muscle size and strength, the influence on fat deposition should not be overlooked. Both resistance exercise and ST has been suggested to promote lipolysis through a variety of mechanisms. Acute resistance exercise stimulates endocrine activities which enhances hormonal secretions (63), namely testosterone, growth hormone, and catecholamines. According to Pratley et al. (97), ST can also increase resting levels of the catecholamine norepinepherine. Lipolysis, in turn is stimulated by the presence of growth hormone (42; 83), and especially catecholamines (7; 99; 129), specifically those binding to β_1-adrenoreceptors (72). Furthermore, an enhanced adipose tissue blood flow, stimulated by norepinepherine (99), and a decreased insulin production contribute to exercise induced lipolysis (7). This increased lipolysis rate in fat cells causes a breakdown of triglycerides into glycerol and free fatty acids, which are

delivered to the blood stream (7). However, resistance exercise itself, and in particular the protocol used in our laboratory (150) which prescribes ~5 minutes of exercise for a small muscle group, requires a relatively low energy expenditure. Exercise recovery may be where lipolysis is enhanced due to the evidence that fat expenditure following a recovery period from aerobic exercise is directly related to growth hormone and epinephrine release (98). A resistance exercise session of moderate intensity and short rest periods intended to stimulate hormonal responses, prior (20 & 120 min) to submaximal aerobic exercise, can strongly enhance fat metabolism evident by elevated blood concentrations of free fatty acids and glycerol along with a lower respiratory exchange ratio (41). In the same analysis, the levels of free fatty acids and glycerol were already elevated following resistance exercise, prior to the subsequent aerobic exercise bout, suggesting that resistance exercise alone can stimulate fat oxidation.

Along with increasing lipid oxidation, resistance exercise, similar to aerobic exercise, can increase RMR (52). However, the most significant affect upon RMR comes with extended ST, especially in men. ST is an effective method of maintaining metabolically active tissue in older adults, thus leading to an increase in energy requirements and RMR (11). Following 16 weeks of full body ST, healthy men (50–65 yr) increased RMR 7.7%, a change that remained significant even after adjustment for FFM (97). Furthermore, a 24 week ST protocol in healthy young and older men and women (20-30 yr, 65-75 yr) produced a 7% increase in absolute RMR for the group as a whole, but when pooled by sex, young and older men showed a 9% increase while women of both ages did not significantly increase (68). After correction for FFM, the same trend existed as the whole group presented a significant

increase in RMR yet when analyzed individually, the only groups that increased were the two sets of men (68). When studied independently, RMR also did not change in healthy older women following ST of various intensities after up to a years time (130). Contrary to this data, postmenopausal women have shown the ability to increase RMR with ST, although this change can not be completely attributed to an increase in FFM as the significance in change was lost once lean mass was corrected for (115; 139). Together this data suggests that ST can improve RMR in both young and old adults with the response being affected by sex.

Finally, genetics can also influence the regional body fat response to ST. Data from our group (150) demonstrated the same ST protocol used in the present study reduces IMF in older subjects who carry the adrenergic (ADR) β2 Glu27 allele alone or with ADRα2b Glu^9 allele. However, when analyzed as a whole group independent of genotypes, ST did not influence IMF (150).

Summary

In summary, skeletal muscle mass begins to steadily decline as early as the 40s. This loss of muscle mass, termed sarcopenia, is of critical importance in the lower limbs as it is associated with decreased strength, mobility loss, and even mortality. Aging is also associated with increased fat infiltration in and around the muscle which in turn is associated with mobility loss and insulin resistance. Regional body composition, analyzed most effectively with imaging techniques, can vary among individuals of a given sex and race. Baseline data demonstrates sedentary older men and African-Americans have more absolute muscle mass than women and

Caucasians respectively, while women and African-Americans of both sexes have greater fat infiltration in the thighs.

Strength training has become the intervention of choice for the prevention and treatment of the adverse effects of sarcopenia because of its proven ability to not only increase strength, but skeletal muscle mass as well, in addition to the possibility of improving regional fat composition in older adults. While the effect of sex has been analyzed, with men showing a greater absolute gain in skeletal muscle mass than women, race has not been used as an independent variable in such longitudinal strength training studies. Therefore, an analysis using a large sample size, such as the present one, is necessary to further understand the effect of sex and race on regional body composition (muscle mass, intermuscular fat, and subcutaneous fat) changes resulting from strength training in older adults.

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