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Resistance Training Congruent With Minimal Guidelines Improves Function in Older Adults: A Pilot Study

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Abstract

Background—To examine the effectiveness of the American College of Sports Medicine (ACSM) and the American Heart Association (AHA) resistance training (RT) guidelines to improve physical function and functional classification in older adults with reduced physical abilities.

Methods—Twenty-five at-risk older adults were randomized to a control (CON = 13) or 8-week resistance training intervention arm (RT = 12). Progressive RT included 8 exercises for 1 set of 10 repetitions at a perceived exertion of 5–6 performed twice a week. Individuals were assessed for physical function and functional classification change (low, moderate or high) by the short physical performance battery (SPPB) and muscle strength measures.

Results—Postintervention, significant differences were found between groups for SPPB—Chair Stand [$F(1,22) = 9.14$, $P < .01$, $\eta = .29$] and SPPB—Total Score [$F(1,22) = 7.40$, $P < .05$, $\eta = .25$]. Functional classification was improved as a result of the intervention with 83% of participants in the RT group improving from low to moderate functioning or moderate to high functioning. Strength significantly improved on all exercises in the RT compared with the CON group.

Conclusions—A RT program congruent with the current ASCM and AHA guidelines is effective to improve overall physical function, functional classification, and muscle strength for older adults with reduced physical abilities.

Keywords

functional health and performance; weight training; exercise; gerontology; disability; community-based research

Impairments to physical function are an influencing factor on the health, ability and disability experiences of older adults. Through a combination of health status, lifestyle, and the natural effects of aging, older adults are susceptible to activity limitations and participation restrictions that can have a significant impact on the quality of life for the

individual, their family, and the community. It has been reported that nearly two-thirds of older adults have difficulty performing specific tasks necessary to carryout activities of daily living.¹ With the population shift that is expected to occur as a result of increasing life expectancy and the graying of the Baby Boom generation by 2030,² a significant portion of our population may be at risk for functional limitations.

Accordingly, there has been significant effort to elucidate effective intervention strategies to maintain and enhance physical function. It has been suggested that resistance training may fulfill this need. Though not initially accepted as safe and effective for older adults, this form of physical activity is now recognized as essential to maintain independence and quality of life in this population. In addition to beneficial health effects such as weight, bone, and strength maintenance, possibly the greatest impact of resistance training in this population is to hasten or reverse reductions in physical function. Several studies have provided evidence to suggest resistance training is effective to improve physical function in older adults.³⁻⁶

An abundance of research has been conducted to determine which characteristics describe the most appropriate resistance training program for the older adult population. Program variables, such as intensity, frequency, and volume of training, have been manipulated to create a strong body of evidence that has informed the crafting of population-specific resistance training guidelines. In 2007, the American College of Sports Medicine (ACSM) and American Heart Association (AHA) published the first resistance training recommendation specifically for older adults⁷ to accompany the ACSM's 1998 position stand on resistance training for healthy adults of all ages.⁸ To our knowledge, only 1 study⁹ has specifically examined the effectiveness of the previous guidelines, and no study has yet examined the new guidelines, as an intervention to increase physical function in older adults.

Therefore, it was the primary purpose of this study to examine the effectiveness of the current resistance training guidelines for older adults proposed by ACSM/AHA to improve physical function in individuals with reduced physical abilities. A randomized controlled intervention trial was used to compare change in physical function pre- and postintervention between a treatment group receiving the minimum recommendations of the guidelines and a control group asked not to change their physical activity participation. To better understand the clinical significance of such an occurrence, a secondary purpose was to determine if older adults with reduced physical abilities who adhere to the recommended intervention dosage will experience a change such that they can be reclassified to a more favorable level of functioning. It was hypothesized that the minimum recommended dosage of the guidelines would be sufficient to both improve physical function and improve functional classification in older adults with reduced physical abilities.

Methods

Participants

Seventy-seven volunteers were recruited from the community and area senior centers via word of mouth, flyers, and announcements. Eligibility was contingent upon appropriate age, initial level of functioning, and medical status. Participants were excluded if they were

younger than 65 years of age, classified as high-functioning, participated in resistance training during the past 6 months, or had any physical or mental-health related contraindications to the intervention. Functional classification was determined using the short physical performance battery (SPPB) and is operationally defined in the Study Measures section. Physical contraindications included cardiovascular complications, such as myocardial infarction, major heart surgery, stroke, and deep vein thrombosis; and orthopedic complications, such as hip fracture, rotator cuff/labral tears, and hip/knee replacements, in the past 6 months. In addition, participants were excluded if they had severe arthritis or uncontrolled hypertension (defined as systolic blood pressure ≥ 160 mmHg and/or diastolic blood pressure ≥ 100 mmHg). Mental-health related complications included inadequate cognitive ability (operationalized as inability understand and willingly consent to an informed consent document) or clinical diagnosis of a psychiatric disorder such as depression, anxiety, or psychosis. All participants provided written, informed consent. This study was approved by the University's ethics committee. Twenty-six were excluded by the initial screening process. The remaining 51 were scheduled for a pretesting and orientation session where further inclusion criteria were considered. Of the 51 scheduled, 4 did not show and 47 underwent the preassessment. The 27 who did qualify for the study were included as participants and were randomly assigned to a resistance training group (RT group) or control (CON group). All 12 participants randomized to the RT group successfully completed the study by attending at least 80% of training sessions and all testing sessions. Thirteen of 15 participants randomized to the CON group successfully completed the study by attending all testing sessions. Of the 2 participants who did not successfully complete the study, 1 was not able to be reached for the posttesting and debriefing session and 1 had a change in health status during the trial period that prevented completion. There were no differences between baseline characteristics of the 2 who were unavailable at follow-up compared with those remaining in the pilot trial.

Study Design and Interventional Structure

The total length of the study was 10 weeks. A pretesting and orientation period during Week 1 was followed by 8 weeks of intervention and 1 week of posttesting. During the pretesting and orientation period, participants were screened for eligibility, randomized, and underwent baseline assessments. For those randomly assigned to the RT group, the intervention period consisted of a 2-week lead-in training period, designed to gradually introduce participants to the stimulus, and 6 weeks of normal training at the required dosage. Those randomly assigned to the CON group were asked to refrain from participating in additional physical activity beyond their daily routine. All participants returned for a posttesting session during Week 10, at which time all baseline assessments were repeated.

Training

A resistance training program was designed to adhere to the minimum recommended dosage according to the ACSM and AHA guidelines.⁹ Therefore, 8 exercises were performed at a moderate intensity for 1 set of 10 repetitions, twice a week for the 8-week intervention period. The following exercises were chosen to best represent whole-body training: lat pulldown, leg curl, leg press, calf raise, hip abductor, chest press, abdominal, and upper back. These exercises were performed on Keiser (Fresno, CA) strength equipment, which

uses pressurized air to generate resistance and provides a digital readout of the weight being lifted. The order in which the exercises were presented was randomized and the initial weight for each exercise was determined during a preliminary strength testing session (described below). Intensity of the exercise was monitored using the Borg CR-10 scale of perceived exertion¹⁰ and was to remain at a 3–4 during the 2-week lead-in period, increasing to 5–6 during the 6 weeks of normal training. Participants were introduced to the perceived exertion scale, shown its functions and verbal anchors, and described how it was to be used. To ensure proper adherence to the recommendations and that the resistance training program remained progressive, all training sessions were supervised and participants' perceived exertion and strength were reassessed daily for each exercise by the investigators. If the participant rated the resistance as too heavy or light, it was adjusted during the following training session by 5 pounds for upper-limb exercises and by 10 pounds for lower-limb and core exercises.

Study Measures

Physical Function and Classification of Functional Ability—The short physical performance battery (SPPB) was administered by the same investigator, according to the procedures described by Guralnik et al.¹¹ Briefly, the battery consists of 3 tasks designed to assess gait speed, and ability to rise from a chair and maintain standing balance. To test gait speed, participants were asked to walk at a preferred pace across an 8-foot course with a 2-foot lead-in and lead-out. The walk was performed for 2 trials with the faster of the 2 recorded. To test the ability to rise from a chair, participants were asked to stand-up and sit-down 5 times as quickly as possible from a straight-backed chair with their arms folded across the chest. The time taken to complete 5 full chair stands with the participants back in contact with the chair was recorded. Lastly, full-tandem (toe of 1 foot directly behind the heel of the other), semitandem (toe of 1 foot even with heel of the other), and side-by-side (heels of both feet even) standing tasks were used to test the ability to maintain standing balance. Each trial began as the participant released hold of their spotter (an investigator) and ended when the participant either moved their feet, grasped for support, or the maximum time elapsed.

Each task was scored according to Guralnik et al.¹² which used cut-points based on quartiles of performance previously calculated from the Established Populations for Epidemiologic Studies of the Elderly,¹³ with 0 representing inability to perform a task and 4 indicating maximum performance. A summary performance score was calculated by adding the performance scores from each test. Thus, the maximum possible score is 12. Using cut-offs based on relative risk for disability from Guralnik et al,¹² participants were classified as low, moderate, or high functioning based on summary scores ranging from 4–6, 7–9, and 10–12, respectively. These classifications were used in the current study for inclusionary purposes (SPPB ≥ 9) and to examine the concept of functional reclassification as the result of the intervention.

Muscle Strength—Formal strength testing sessions took place during Weeks 1 and 10, with an additional practice session during Week 1 to help adjust for the possibility of a learning effect. The goal for this testing was to determine a resistance that elicited a

perceived exertion of 3–4 out of 10 on the Borg CR10 Scale of perceived exertion.¹⁰ A corresponding resistance was found for each exercise. The process began with an investigator first selecting a best-estimated weight. The participant was then instructed to perform the exercise for 10 repetitions and report their perceived exertion. If the participant rated the resistance as too heavy or light, it was altered accordingly by 5 pounds for upper-limb exercises and by 10 pounds for lower-limb and core exercises. When the appropriate resistance had been found for each exercise, it was recorded.

Physical Activity Participation: To account for the possible influence of altered physical activity participation on physical function throughout the intervention, the Physical Activity Scale for the Elderly (PASE)¹⁴ was administered during Weeks 1 and 10. This questionnaire assesses the self-reported frequency and duration of household, occupational, and leisure-time activities typically performed in a typical week. The PASE has demonstrated validity and reliability,¹⁴ and has shown a significant moderate correlation ($r = .64$, $P < .05$) with more expensive objective methods of physical activity measurement such as accelerometry. Participants were instructed to read each question carefully and answer truthfully.

Statistical Analyses

All variables were examined for normality before analysis and descriptive statistics were calculated. Differences between groups for baseline demographics, physical function, muscle strength, and physical activity participation were analyzed using independent samples t tests. One-way between-groups analysis of covariance (ANCOVA) adjusting for baseline differences was used to determine postintervention differences between groups for the primary outcome of physical function and secondary outcomes of muscle strength and physical activity participation. Changes in functional classification were determined by tracking changes in SPPB—Total Score from pre- to postintervention. All statistical analyses were conducted using SPSS Version 16.0 for Windows (Chicago, IL) with alpha set at 0.05.

Results

Baseline Characteristics

As a whole, the study sample had an average age of 73.1 ± 6.2 years and was considered obese with a BMI of 30.0 ± 4.3 . The majority of participants were female (60%), Caucasian (84%), and middle to upper socioeconomic status. The average number of current chronic conditions was 2.7 ± 1.7 ; however, these conditions did not inhibit participation in physical activity as all participants were required to receive physician's consent to be considered for inclusion in the study. Most participants (96%) were classified as having a moderate level of physical functioning at baseline. Complete demographic information for participants that completed the study is presented in Table 1. There were no significant statistical differences between the RT and CON groups for any descriptive variables.

Physical Function and Classification of Functional Ability

Objectively measured physical function as assessed using the SPPB was significantly improved in the RT group compared with the CON group, see Table 2. Statistical

differences were found between groups at postintervention for the SPPB subscore of Chair Rise [$F(1,22) = 9.01$, $P < .01$, $\eta^2 = .29$] and the SPPB—Total Score [$F(1,22) = 7.40$, $P < .05$, $\eta^2 = .25$].

A graphical representation of changes to physical functional classification according to the SPPB—Total Score can be found in Figure 1. Ten participants (83.3%) in the RT group improved their functional classification as a result of the intervention. Nine improved their classification from moderate to high functioning, and 1 from low to moderate functioning. Changes in functional classification for the CON group ($n = 13$) were less uniform than those of the RT group. Seven participants (54%) maintained their classification from pre- to post-intervention, while an improvement from moderate to high functioning was measured in the remaining 6. Of those 6, 4 improved their SPPB—Total Score by 1 point from 9–10.

Muscle Strength

Postintervention values of both groups for the 8 RT exercises are displayed in Table 3. Significant improvements in strength were experienced by the RT group compared with the CON group. The main effect for group was statistically significant at $P < .001$ for lat pulldown [$F(1,21) = 19.36$, $\eta^2 = .48$], chest press [$F(1,22) = 39.32$, $\eta^2 = .64$], abdominal [$F(1,22) = 51.77$, $\eta^2 = .70$], upper back [$F(1,22) = 29.82$, $\eta^2 = .58$], leg press [$F(1,22) = 43.66$, $\eta^2 = .67$], leg curl [$F(1,21) = 16.69$, $\eta^2 = .46$], hip abductor [$F(1,23) = 25.42$, $\eta^2 = .54$], and calf raise [$F(1,23) = 55.41$, $\eta^2 = .72$] exercises.

Further analysis was done to examine the normal training period to verify that the intensity of each exercise was maintained at the proper dosage. Data from the daily intensity checks were examined to determine the weekly percentage of participants that did not rate perceived exertion beyond the minimum intensity specified by the guidelines. Perceived exertion rated below a 7 was considered to be adherence to the guidelines, while a rating above a 7 was not. For the most part, participants did not surpass the maximum allowed intensity of 6 on a 10 point scale of perceived exertion. There were only 4 occasions (out of a possible 48) where the average weekly intensity for a specific exercise fell below 80% adherence.

Physical Activity Participation

No statistically significant changes in PASE scores were found in the RT group (106.12 ± 40.94 to 101.19 ± 39.16 , $P = .67$) or the CON group (111.96 ± 50.99 to 106.43 ± 62.47 , $P = .65$). In addition, no differences were found between groups at postintervention [$F(1,22) = 4.35$, $P = .96$, $\eta^2 = .00$]. Therefore, alterations to physical activity participation are an unlikely explanation for the improvements in physical function.

Discussion

The purposes of the current study were to 1) examine the effectiveness of the current recommendations for RT by the ACSM and AHA (8 exercises, 1 set, 10 repetitions, 2 days/wk, 5–6 on a 10-point scale of intensity) to improve objectively assessed physical function in a group of community dwelling older adults with reduced physical abilities, and 2) determine if older adults with reduced physical abilities who adhere to the

recommendations will experience a change that improves their functional classification. According to our results, both the primary and secondary hypotheses of the current study were accepted. The training program was shown to improve physical function in the RT group when compared with the CON group, and findings from secondary analyses suggest that the improvements were likely not the result of changes in physical activity participation during the intervention. Functional classification was also improved as a result of the intervention. A majority (83%) of participants in the RT group were reclassified from a low to moderate functioning or a moderate to high functioning level. Lastly, muscle strength was improved as a result of the intervention, as the between group effect was statistically significant for all 8 RT exercises.

Short Physical Performance Battery

The main finding of the current study was that the RT program was effective to improve physical function according to the SPPB. Significant improvements within the RT group were found for the SPPB subscore of Chair Rise, which contributed to an overall improvement in SPPB—Total Score. Improvements in SPPB—Total Score adjusted for baseline scores were 2.98 points (38.45%) for the RT group and 0.39 points (4.49%) for the CON group. Groups were statistically different postintervention.

Several controlled trials have used the SPPB as an outcome measure to explore the effectiveness of an intervention that includes RT to improve physical function in older adults.^{15–17} In general, our results are in agreement with previous research, but improvements as a result of the intervention used in the current study are greater than those found in these studies. We believe it is a lack of focus on RT as the primary stimulus for the intervention in other studies that explains this discrepancy. For instance, the Lifestyle Interventions and Independence for Elders Pilot (LIFE-P),⁷ one of the more seminal studies in the areas of physical activity interventions and physical function, and Bastone Ade and Jacob Filho¹⁵ both used multimodal interventions including aerobic, strengthening, and functional exercises. At 6 months, improvements in SPPB—Total Score for the LIFE-P study were 1.2 points (16%) for the intervention group and 0.5 points (6.66%) for the control group. These scores were adjusted for gender, field center, and baseline values. Similarly, Bastone Ade and Jacob Filho¹⁵ found unadjusted improvements in SPPB—Total Score of 1.11 points (16.66%) for those in the exercise program and a decrement of 0.95 points (–15.73%) for the nonexercise control. With both studies, there is no way to separate out the independent effects of RT on physical function. The current study, on the other hand, was able to demonstrate that improvements in physical function were independent of changes to overall physical activity participation and were likely the result of RT alone.

Our findings are most similar to Nelson et al¹⁶ who used a 6-month randomized controlled intervention similar to that of the current study to compare changes in function between a home-based exercise program and a nutrition education control. Participants completed body weight exercises, lower and upper body strength training with weights, and balance training exercises, 3 times per week for 2 sets of 8 repetitions at an intensity of 7–8 on a 10-point Borg perceived exertion scale. It was reported that SPPB—Total Score improved by 26% in exercisers and decreased by 1.2% in controls. The improvement in the RT group of the

current study was slightly higher, but a likely explanation for this discrepancy is a lack of continued supervision in the Nelson et al study.¹⁶ After 6 initial training sessions during the first month, the exercise group in this study had contact with the study's investigators only once per month thereafter. Conversely, the current study was strictly supervised during each training session for the duration of the intervention to ensure compliance and progression.

Functional Classification

Findings from the current study were also able to demonstrate the effectiveness of the current ACSM and AHA guidelines to improve functional classification according to the SPPB. To our knowledge, this study is one of the first of its kind to do so as the result of a focused RT intervention. For this reason, it is difficult to determine if the findings of this study are comparable to those of previous research in this regard. However, an understanding about the importance of changing functional classification can be gleaned from analyses of Established Populations for Epidemiologic Studies of the Elderly data. Findings from Guralnik et al¹² showed participants with a score of 7–9 to have an adjusted relative risk of 1.8 to develop mobility disability and 1.6 to develop disability in activities of daily living when compared with those having a score of 10–12 after 4 years of follow-up. This risk is increased to 4.2 and 4.9, respectively, for those with a score between 4–6.

In the current study we found 10 participants in the RT group improved their functional classification; 9 from a moderate to high level and 1 from a low to moderate level. By extending the findings of Guralnik et al,¹² it becomes possible therefore, to suggest that the relative risk for developing future mobility and disability in activities of daily living may have been reduced in the current sample.

Muscle Strength

In the current study, strength increases ranged from 129%–212% in the RT group from pre- to postintervention. The average strength increase for all 8 exercises was approximately 164%. Meanwhile, muscle strength in the CON group either stayed the same or decreased slightly. These findings are confirmatory of other studies with RT programs targeting the whole body,^{5,18} including both upper and lower extremity exercises in older adults.

This study has several limitations. Investigators were not blinded to group assignment. This may have unintentionally caused bias on the part of the tester. In addition, we used self-report to rule out physical activity as a rival explanation for improvements in physical function during the intervention period. Though this method may not have the sensitivity and protection from bias as more objective methods, we feel the PASE is adequate for its purpose in this study. Another limitation is that the findings of this study were the result of an RT program under direct supervision. Though the ACSM and AHA guidelines make no mention of the need for supervision to ensure the effectiveness of a program or that it may be more appropriate for certain populations, we chose to directly supervise all sessions to maintain safety and a strict experimental environment. Therefore, these results cannot be generalized to unsupervised RT. Lastly, because access to fitness facilities and constant supervision is limited in the older adult population, future research should compare the

effectiveness of RT interventions with varying degrees of supervision to determine the most practical approach that yields the greatest benefits.

Conclusion

The current study was able to show that a resistance training program congruent with the minimum recommended dosage of the current ASCM and AHA guidelines performed under supervision is effective to improve overall physical function, functional classification, and muscle strength for older adults with reduced physical abilities. The findings of this study indicate that moderate intensity resistance training performed twice a week can offer substantial and meaningful improvements. The promotion of these RT guidelines for older adults with reduced physical abilities is recommended as a supplement to regular physical activity and aerobic exercise, as they represent an excellent means to reverse losses to strength and physical function associated with aging. Future studies are warranted in larger more diverse samples to extend the findings of the current study.

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Figure 1.

Change in functional classification according to SPPB—Total Score from preintervention to postintervention for resistance training (RT) and control (CON) groups. *Note.* Each line represents an individual or multiple participants with the same scores from pre- to postintervention.

Table 1

Participant Characteristics

Variable	All (N = 25)	RT group (n = 12)	CON group (n = 13)
Age (yr)	73.1 ± 6.2	75.1 ± 6.6	71.3 ± 5.4
Gender			
Male	n = 10	n = 7	n = 3
Female	n = 15	n = 5	n = 10
Height (cm)	171.6 ± 10.3	174.3 ± 9.4	169.1 ± 10.8
Weight (kg)	86.3 ± 13.3	89.8 ± 13.7	83.1 ± 12.5
BMI (kg/m ²)	30.0 ± 4.3	29.6 ± 4.7	30.3 ± 4.0
Race			
Caucasian	n = 21	n = 9	n = 12
African American	n = 4	n = 3	n = 1
Marital status			
Single	n = 5	n = 3	n = 2
Married	n = 11	n = 5	n = 6
Divorced	n = 6	n = 2	n = 4
Widowed	n = 3	n = 2	n = 1
Income			
< \$30,000	n = 12	n = 7	n = 5
> \$30,000	n = 11	n = 4	n = 7
No response	n = 2	n = 1	n = 1
Highest degree achieved			
None/elementary	n = 2	n = 2	n = 0
High school	n = 6	n = 1	n = 5
College/advanced	n = 17	n = 9	n = 8
Chronic conditions	2.7 ± 1.7	2.8 ± 2.2	2.7 ± 1.3
SPPB classification			
Low functioning [*]	n = 1	n = 1	n = 0
Moderate functioning ^{**}	n = 24	n = 11	n = 13
High functioning ^{***}	n = 0	n = 0	n = 0

Note. Values are M ± SD unless otherwise stated.

Abbreviations: RT, resistance training; CON = control; SPPB = Short Physical Performance Battery.

^{*} Low = a score of 0–6;

^{**} Moderate = a score of 7–9,

^{***} High = a score of 10–12.

Table 2

Pre- and Postintervention Short Physical Performance Battery Scores as a Function of Group Assignment

	RT group		CON group	
	Pre	Post	Pre	Post
Balance	3.0 ± 0.3	3.6 ± 0.2	3.8 ± 0.1	3.8 ± 0.2
Chair rise [†]	1.2 ± 0.2	2.9 ± 0.3	1.2 ± 0.1	1.8 ± 0.3
Gait speed	3.6 ± 0.1	3.9 ± 0.1	3.8 ± 0.1	3.8 ± 0.1
Total score [*]	7.8 ± 0.3	10.7 ± 0.4	8.7 ± 0.1	9.1 ± 0.4

Note. Values are M ± SEM. *P*-values are RT > CON on postintervention scores with preintervention scores considered as a covariate.

Abbreviations: RT, resistance training; CON = control.

^{*} *P* < .05;

[†] *P* < .01.

Table 3

Pre- and Postintervention Strength Scores as a Function of Group Assignment

Exercise	RT group		CON group	
	Pre	Post	Pre	Post
LP [†]	42 ± 2	60 ± 3	40 ± 3	41 ± 3
CP [†]	50 ± 3	75 ± 2	59 ± 2	57 ± 2
Ab [†]	27 ± 3	58 ± 3	28 ± 3	29 ± 3
UB [†]	39 ± 2	63 ± 4	39 ± 3	36 ± 3
LP [†]	152 ± 7	253 ± 11	162 ± 6	147 ± 11
LC [*]	16 ± 1	28 ± 2	17 ± 2	16 ± 2
HA [†]	55 ± 2	82 ± 4	57 ± 3	55 ± 4
CR [†]	108 ± 4	201 ± 9	12 ± 4	110 ± 8

Note. Values represent the group average in weight (lbs.) lifted for each exercise during the strength testing sessions. Values are M ± SEM. *P*-values are RT > CON on postintervention scores with preintervention scores considered as a covariate.

Abbreviations: LP, lat pulldown; CP, chest press; Ab, abdominal curl; UB, upper back; LP, leg press; LC, leg curl; HA, hip abductor; CR, calf raise.

* $P < .01$

[†] $P < .001$.