The Effect of Resistance Training on Functional Capacity and Quality of Life in Individuals with High and Low Numbers of Metabolic Risk Factors

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OBJECTIVE — There are limited data on the effects of resistance training on the capacity to perform activities of daily living (ADLs) and quality of life (QoL) for individuals with a high number of metabolic risk factors (HiMF). In this study, we examined the effect of resistance training on the capacity to perform ADLs and QoL in individuals with HiMF and compared any benefits with individuals with a low number of metabolic risk factors (LoMF).

RESEARCH DESIGN AND METHODS — Fifty-five untrained individuals, aged 50.8 ± 6.5 years, were randomized to four groups: HiMF training (HiMFT), HiMF control, LoMF training (LoMFT), and LoMF control. At baseline and after 10 weeks of resistance training, participants underwent anthropometric measurements and assessments of aerobic power ($V\text{O}_{2\text{peak}}$), muscle strength, capacity to perform ADLs, and a self-perceived QoL questionnaire. A repeated-measures ANOVA was used to examine the effect of training over time among groups.

RESULTS — Training increased lean body mass in both HiMFT ($P = 0.03$) and LoMFT ($P = 0.03$) groups. Total fat content and $V\text{O}_{2\text{peak}}$ improved in the LoMFT group only. Muscle strength improved in both training groups ($P < 0.01$). Time to complete ADLs was reduced by 8.8% in the LoMFT group ($P < 0.01$) and 9.7% in the HiMF group ($P < 0.01$). Only the HiMFT group reported improvement in QoL.

CONCLUSIONS — Resistance training improved muscle strength and the capacity to perform ADLs in individuals with HiMF and LoMF. Resistance training improved QoL for the HiMF group, and this result was independent of changes in body fat content or aerobic power. Longer training regimens may be needed to improve QoL in individuals with LoMF.

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Individuals with at least two metabolic risk factors (high number of metabolic risk factors [HiMF]) have a high risk for developing metabolic syndrome and heart disease (1,2). Low muscle strength, leading to impaired functional capacities and quality of life (QoL), is a common characteristic of patients with HiMF and type 2 diabetes, and, as such, increases in muscle strength and mass are important goals for exercise interventions for these individuals (3).

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Abbreviations: 1RM, one repetition maximum; ADL, activities of daily living; HiMF, high number of metabolic risk factors; HiMFC, HiMF nonexercise control; HiMFT, HiMF training; LBM, lean body mass; LoMF, low number of metabolic risk factors; LoMFC, LoMF nonexercise control; LoMFT, LoMF training; PPT, Physical Performance Test; QoL, quality of life; SF-36, Short Form-36.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

Although the benefits of aerobic training are well documented for individuals with metabolic syndrome and type 2 diabetes, more studies are needed to examine the effects of resistance (strength) training for the HiMF population (3,4). Preservation of muscle strength via resistance training may be an important mediator of age- and diabetes-related sarcopenia and may also have important implications for functional outcomes (5–7). The improvement in the capacity to perform ADLs is important, as it is thought by some to be a surrogate for QoL (8). Although some investigators have reported improvements in QoL of elderly individuals after resistance training (9), others have reported no improvement in QoL (10).

To date, there are limited data on the effects of resistance training as a single intervention on QoL and the capacity to perform ADLs for middle-aged individuals with HiMF. Also, there are limited data on the benefits of resistance training for individuals with HiMF, compared with those with one or no risk factors (low number of metabolic risk factors [LoMF]). Therefore, this study examined the effect of resistance training on the capacity to perform ADLs and QoL in individuals with HiMF compared with those with LoMF. We hypothesize that individuals with HiMF will benefit more from resistance training than individuals with LoMF, on the basis that the former diverge further from healthy risk profiles at baseline.

RESEARCH DESIGN AND METHODS

Fifty-five untrained men ($n = 28$) and women ($n = 27$) aged 50.8 ± 6.5 years (range 40–69 years) volunteered to participate in the study. Each participant was classified as either HiMF (greater than or equal to two metabolic risk factors) or LoMF (less than or equal to one metabolic risk factor), according to the number of metabolic risk factors as published by the International Diabetes Federation (11). After the initial allocation into HiMF and LoMF groups, participants were randomly allocated to one of four groups: HiMF training (HiMFT), HiMF nonexercise control (HiMFC), LoMF training (LoMFT), and LoMF nonexercise control (LoMFC). Participants were taking a range of medications, including β-blockers ($n = 2$), calcium channel blockers ($n = 2$), ACE inhibitors ($n = 4$), diuretics ($n = 1$), statins ($n = 2$), metformin ($n = 1$), and hormone replacement therapy ($n = 6$). Participants were included if they had not been involved in regular aerobic physical activity in the previous 6 months or resistance training in the previous 5 years. Participants were excluded if they had documented cardiac disease. Each participant received written and verbal explanations about the nature of the study before being invited to give informed consent. The study protocol was approved by the Human Research Ethics Committees of both Victoria University and Austin Health.

Study protocol

Participants underwent an initial assessment to determine the number of metabolic risk factors. At baseline and after 10 weeks of resistance training, participants completed a 3-day dietary log and underwent a series of anthropometric measurements, assessment of their aerobic power ($\dot{V}O_{2peak}$) and muscle strength, a series of tests that together assessed functional capacity, and a self-perceived QoL questionnaire. For all measurements that were affected by tester technique, the same investigator took the measurements at baseline and at the end point.

Overnight fasting blood test. A blood sample was collected after a 12-h fast. Blood was analyzed (SYNCHRON LX System/Lxi725; Beckman Coulter, Fullerton, CA) for triglyceride, HDL, glucose, and insulin levels.

Blood pressure. Blood pressure was measured using a mercury sphygmomanometer after the participant had rested in a seated position for 15 min. Systolic and diastolic blood pressures were recorded to the nearest 2 mmHg.

Three-day dietary logs. Participants received a kitchen scale (model KCHC-009; NingBo Leilei Group Co., NingBo, China) and were requested to record dietary intakes for 2 consecutive weekdays and either a Saturday or Sunday. The logs were analyzed by FoodWorks Professional software (Edition 2006; Xyris Software, Highgate Hill, Queensland, Australia). Participants were encouraged not to alter their diet during the study.

Anthropometric measurements. Weight was measured without clothes using a scale (August Sauter, Albstadt, Germany) to the nearest 0.05 kg. Waist circumference was measured with a steel tape and taken as the smallest circumference between the iliac crest and the lower border of the ribs. Three measurements were taken, and the mean of the two closest measures was recorded.

Dual-energy X-ray absorptiometry (GE Lunar Prodigy, software version 9.1; GE Healthcare, Madison, WI) was used to assess total body fat, total body fat percentage, and lean body mass (LBM). Dual-energy X-ray absorptiometry measurements were performed at the Bone Density Unit at Austin Health.

Aerobic fitness. Aerobic power ($\dot{V}O_{2peak}$) was assessed during a symptom-limited graded exercise test on a Cybex MET 100 exercise cycle (Cybex Metabolic Systems, Ronkonkoma, NY). The protocol consisted of an initial intensity of 25 W, with increments of 20 W/min for men and 10 W/min for women. The tests were terminated when participants' ratings of perceived exertion reached "very hard" (Borg scale = 17) (12) or on the appearance of clinical signs or symptoms. $\dot{V}O_2$ for each 15-s interval was measured by gas analysis (Cardio2 and CPX/D System with Breezeex Software, 142090-001; Medgraphics, Revia, MN) that was calibrated before each test.

Physical Performance Test. The Physical Performance Test (PPT) was based on the method of Reuben and Siu (13), with modifications by Brandon et al. (7) and Nichols et al. (14). The protocol included four functional mobility tasks consisting of a 15-m rapid walking test, an up-and-go test, and stair climbing and stair descending. All tests were scored as time (seconds). In the 15-m rapid walking test, participants were instructed to walk at a fast but safe pace. In the up-and-go test the participant was asked to rise from a standard chair, walk 3 m, and return to a seated position on the chair. The stair tests consisted of a rapid ascent and descent of 22 stairs while the participant was wearing a vest with weights evenly distributed around the torso corresponding to 15% of body mass. Participants rested between the ascent and descent for 45 s. Participants underwent four attempts on each task with 40-s rest intervals, and the best time for each test was reported. The PPT score was the sum of the fastest times for each of the four tests.

Muscle strength. Total body muscle strength was evaluated using the one repetition maximum (1RM) method for seven different resistance exercises. The exercises consisted of chest press, leg press, lateral pulldown, triceps push-down, knee extension, seated row, and biceps curl. 1RM was defined as the heaviest weight a participant could lift just once with a proper lifting technique, without compensatory movements. The protocol consisted of one session of familiarization followed by two 1RM tests separated by ~1 week. The best result for each exercise from the two tests was considered as the 1RM. Total body muscle strength was calculated as the sum of the seven exercises.

Short Form-36. The Short Form-36 (SF-36) is a widely used instrument for self-perceived physical and mental QoL (15,16) and was completed before the PPT.

Resistance training protocol

The resistance training program was performed 3 days per week for 10 weeks, with a 48-h recovery between sessions. Training consisted of the seven exercises that were used in the 1RM strength tests. In addition, participants performed one abdominal exercise (abdominal curl). Each training session included a 3-min warm-up and 50–60 min of resistance exercise. The training exercises were based on the recommendations of the American College of Sports Medicine for individuals with insulin resistance and type 2 diabetes (17). During week 1, participants performed two sets of 15–20 repetitions at intensities that corresponded to 40–50% 1RM. During week 2, participants performed three sets of 15–20 repetitions at intensity corresponding to 50–60% of 1RM. Between weeks 3 and 6, the number of repetitions was reduced to 12–15 while intensity increased to 60–75% of 1RM. In the final 4 weeks of training, the number of repetitions was 8–12, with intensity corresponding to 75–85% of 1RM. For each session, weights were adjusted according to the current capacity of the individual, with weights being increased if the participant was able to achieve the maximum number of prescribed repetitions for that week and decreased if the participant was unable to achieve the minimum number of repetitions. All training sessions were supervised by an exercise physiologist.

Table 1—*Characteristics of the groups at baseline*

Variable	LoMFC	LoMFT	*P* value	HiMFC	HiMFT	*P* value
n	13	12		15	15	
Sex (male/female)	4/9	4/8	—	10/5	10/5	—
Postmenopausal women	1	1		1	3	
Age (years)	48.5 ± 7.7	50.6 ± 5.1	0.43	52.3 ± 5.8	51.6 ± 7.1	0.78
Height (cm)	166.4 ± 8.3	167.4 ± 10.2	0.80	170.9 ± 8.8	169.7 ± 11.1	0.75
Mass (kg)	67.8 ± 12.6	66.8 ± 10.6	0.84	88.3 ± 14.8	90.6 ± 13.4	0.64
Waist (cm)	81.3 ± 8.5	80.9 ± 8.9	0.90	99.0 ± 10.6	104.1 ± 10.4	0.20
BMI (kg/m^2)	24.3 ± 3.4	23.8 ± 3.1	0.70	30.0 ± 3.7	31.6 ± 4.4	0.28
Total fat (%)	34.6 ± 8.0	34.6 ± 10.4	0.99	36.3 ± 8.9	39.3 ± 8.7	0.36
Total LBM (kg)	42.6 ± 10.2	42.4 ± 10.7	0.95	54.3 ± 11.4	53.1 ± 10.7	0.76
Number of risk factors						
Obesity	4	5	—	14	15	—
Dyslipidemia	0	0	—	9	7	—
Hypertension	2	1	—	12	11	—
Impaired fasting glucose	0	0	—	8	8	—
Type 1 diabetes	0	0	—	1	1	—

Data are means ± SD.

Statistics

Multivariate ANOVA was used to examine the differences of the metabolic risk factors between the HiMF group and the LoMF group before individuals in each group were randomly assigned to a training group or nonexercise control group. In addition, multivariate ANOVA was used to examine the characteristics of the groups at baseline after randomization (i.e., HiMFT versus HiMFC and LoMFT versus LoMFC). The training data were analyzed by the repeated-measures ANOVA model, which was constructed to analyze the effect of primary interest by time (before and after) for each group. Repeated-measures ANOVA was also used to examine the effect of training over time between each two metabolic risk groups (i.e., LoMFT versus LoMFC and between HiMFC and HiMFT, referred as "*P* value group × time") and between the two training groups (i.e., LoMFT versus HiMFT, referred as the "*P* value group × time between the two training groups"). Spearman row correlation was performed to assess the correlation between change in muscle strength and QoL and change in muscle strength and the capacity to perform ADLs. All data are reported as means ± SD, and all statistical analyses were conducted at the 95% level of significance.

RESULTS

Metabolic differences between HiMF and LoMF groups

The HiMF group had higher waist circumference (101.5 ± 10.6 vs. 81.1 ± 8.5 cm, $P < 0.01$), systolic (133.3 ± 13.3 vs. 116.7 ± 11.7 mmHg, $P < 0.01$) and diastolic 87.6 ± 8.8 vs. 77.0 ± 6.8 mmHg, $P < 0.01$) blood pressure, and triglycerides (1.5 ± 0.6 vs. 0.7 ± 0.4 mmol/l, $P < 0.01$) and lower HDL (1.5 ± 0.5 vs. 1.8 ± 0.6 mmol/l, $P = 0.02$) compared with the LoMF group. In addition, the HiMF group had higher fasting glucose (5.8 ± 0.8 vs. 5.0 ± 0.3 mmol/l, $P < 0.01$) and insulin (55.9 ± 33.7 vs. 27.6 ± 21.8 pmol/l), $P < 0.01$). There were no significant differences between the LoMFC and LoMFT groups or between the HiMFC and HiMFT groups for sex, age, weight, height, total body fat percentages, and total LBM (Table 1).

Adherence to training

Three participants from the training groups (one from the LoMFT and two from the HiMFT groups) did not complete the study, and their baseline data were excluded. Adherence to training for the HiMFT group was 88% and for the LoMFT group was 96%. At baseline, one participant from the LoMFT group, three from the HiMFC group, and one from the HiMFT group did not complete the 1RM test for the leg extension exercise because each possessed strength exceeding the available loads on the machine. The strength test for leg extension was not conducted at the end point for these individuals. One other participant from the HiMFT group was not tested for leg extension because of an unrelated injury to the knee.

Diet comparison

No changes in total energy intake were observed during the course of the study within each group ($P > 0.20$), and there were no significant interactions between the LoMFC and LoMFT ($P = 0.65$) groups or between the HiMFC and HiMFT ($P = 0.76$) groups. No significant differences were observed between the two training groups ($P = 0.50$). No change was observed in the energy macronutrient composition of the diet within or between groups, with fat contributing ~24%, protein ~22%, and carbohydrate ~54% of total energy intake.

Effect of training on body composition

For both the HiMFT and LoMFT groups, training had no effect on body mass ($P > 0.05$). In the LoMFT group, training had positive effects on waist circumference, total fat percentage, and total fat (in kilograms). For both the LoMFT and HiMFT groups, training significantly increased LBM compared with the corresponding control groups (2.6 and 2.1%, respectively, $P = 0.03$) (Table 2) with no difference between the two training groups ($P = 0.94$).

Effect of training on aerobic power, muscle strength, and the capacity to perform ADLs

In the LoMFT group, training had a positive effect on both absolute and relative $\dot{V}O_{2peak}$ (Table 3). Muscle strength improved for all seven exercises for both training groups compared with their control groups, with mean improvement of

Table 2—*The effect of resistance training on body composition of individuals with LoMF and HiMF*

Variable and group	Before	After	*P* group × time interaction
Waist (cm)			
LoMFC	81.3 ± 8.5	82.9 ± 8.5*	0.05
LoMFT	79.9 ± 8.7	79.6 ± 9.1	
HiMFC	99.0 ± 10.6	99.3 ± 11.3	0.11
HiMFT	102.3 ± 9.9	100.8 ± 9.8	
Total fat (%)			
LoMFC	34.6 ± 8.0	34.9 ± 8.2	0.02
LoMFT	35.0 ± 10.8	33.5 ± 10.5*	
HiMFC	36.3 ± 8.9	36.2 ± 8.3	0.46
HiMFT	39.8 ± 9.2	39.2 ± 9.3	
Total fat (kg)			
LoMFC	22.6 ± 7.1	23.0 ± 7.2	0.08
LoMFT	22.2 ± 7.1	21.5 ± 7.2	
HiMFC	31.1 ± 9.1	30.9 ± 9.1	0.91
HiMFT	33.9 ± 9.1	33.5 ± 8.6	
Total LBM (kg)			
LoMFC	42.6 ± 10.2	42.7 ± 10.3	0.03
LoMFT	41.8 ± 11.1	42.9 ± 10.9*	
HiMFC	54.3 ± 11.4	54.0 ± 11.1	0.03
HiMFT	51.3 ± 10.3	52.4 ± 11.0*	

Data are means ± SD. *P* group × time interactions represent changes between before and after intervention levels for the training groups compared with the control groups, for each group, HiMF and LoMF, analyzed separately. *$P \leq 0.05$ between before and after within each group.

25 and 23.7% (HiMFT and LoMFT groups, respectively) (Table 3). The mean improvement of muscle strength was higher for the HiMFT group than for the LoMFT group ($P = 0.03$).

Total time to complete the PPT was significantly reduced by 8.8% in the LoMFT group and by 9.7% in the HiMFT group compared with the control subjects (both $P < 0.01$), with no difference between the two training groups ($P = 0.78$) (Table 3). In addition, training significantly improved most of the individual components of the PPT ($P < 0.05$) for both training groups, with the exception of the up-and-go test in the HiMFT group compared with the HiMFC group ($P = 0.14$). No significant differences were observed between the two training groups for any components of the PPT.

The change of muscle strength was negatively correlated with time to complete the PPT for both the HiMF group (pooled HiMFT and HiMFC groups, $r = 0.53$, $P < 0.01$) and the LoMF group (pooled LoMFT and LoMFC groups, $r = 0.47$, $P = 0.02$). However, changes in muscle strength in the pooled HiMF group correlated with changes in self-reported physical and mental health ($r = 0.59$, $P < 0.01$ and 0.45 and $P = 0.02$, respectively). This was not evident in the pooled LoMF group data.

Effect of training on QoL

Resistance training had no effect on any of the SF-36 subscales and physical and mental health dimensions for the LoMFT group (all $P > 0.05$). In contrast, for the HiMFT group, training increased the perception of both physical and mental health (12.9 and 8.3%, respectively) compared with the HiMFC group (Table 3). In addition, training improved the scores of the subscales of the SF-36 for the HiMFT including physical function (7.9%), general health (13.5%), and social function (9.8%). Role of physical scale tended to improve in the HiMFT group compared with the HiMFC group (14 and −11.8%, respectively, $P = 0.08$). Training had contrasting influences on the perception of bodily pain between the two training groups. The bodily pain score for the LoMFT group decreased (−8.9%, indicating more perception of bodily pain) after training, whereas the bodily pain score for the HiMFT group increased (improved) by 14.4% ($P = 0.04$). Similarly, training had more positive effects on the self-perceived physical health dimension of the HiMFT group compared with that of the LoMFT group (+12.9 and +0.5%, respectively, $P = 0.06$).

CONCLUSIONS

— The main finding of the current study was that resistance training improved LBM, muscle strength, and the capacity to perform ADLs to a similar extent in the HiMFT and LoMFT groups. This was associated with improved QoL for the HiMFT but not the LoMFT group. Resistance training did not reduce whole body fat content or improve aerobic power ($\dot{V}O_{2peak}$) for the HiMFT group but did improve QoL. In contrast, there was a reduction in whole body fat and improved aerobic power for the LoMFT group in the absence of improvements in QoL.

Muscle weakness is a common finding in adult clinical populations (3,18) and is also a consequence of normal aging (19,20). Resistance training is the preferred training regimen to increase the muscle strength and mass that are important for the performance of ADLs in many populations including young and elderly individuals and those who suffer from chronic diseases (21–23). It is well documented that an increase in muscle strength can improve the capacity to perform ADLs and reduce disability in elderly people (7,8,24). This study showed that improvements in muscle strength in both HiMFT and LoMFT groups were correlated with improvements in the capacity to perform ADLs.

Although both groups improved their capacity to perform ADLs, an increase in QoL was observed only in the HiMF group. It is possible that training had a positive influence on QoL for HiMF, as overweight individuals with and without chronic diseases have lower QoL scores compared with lean individuals or those with less morbidity (25,26). In the present study, the HiMFT group exhibited small positive changes in QoL, whereas the HiMFC group exhibited a small decline. For the LoMF arm of the study, the QoL of the control group did not decline, and the group difference (control versus training) was not significant. It may be that QoL declines for individuals with HiMF who are not involved in regular physical activity, and this decline is not as apparent for individuals with LoMF. An alternative explanation for the lack of change in QoL in the LoMFT group may relate to these individuals having less qualitative dysfunction at baseline. It is possible that in relatively healthy middle-aged and elderly individuals, longer periods of training should be performed to improve QoL (10). It has been suggested that the capacity to perform ADLs may be used as a surrogate for QoL in elderly individuals (8) and those with chronic diseases (27). The current study suggests that there are associations between muscle strength, ADLs, and QoL for individuals with HiMF. Most ADLs do not require high levels of endurance capacity but are better classified as needing short bursts of effort (such as rising from a chair, climbing stairs, dressing, and carrying groceries). Therefore, improvements in muscle strength may be more appropriate, compared with endurance-type training regimens, to improve the capacity to perform ADLs and QoL.

Resistance training had a positive effect on LBM for both training groups. This finding is concordant with other studies that examined the effect of resistance training for individuals with metabolic disorders, such as type 2 diabetes (28,29). In the present study, it appears that training had more favorable effects on total fat content for the LoMFT group. In the LoMFT group, waist circumference did not change, but it increased in the LoMFC group. Resistance training reduced total fat and fat percentages for the LoMFT group compared with the LoMFC group. In contrast, resistance training had no effect on any of the fat measurements in the HiMF groups (training and control). There are at least two factors that may limit fat loss after resistance training in overweight individuals and those with other metabolic risk factors, including insulin resistance. First, the HiMF groups had higher fasting insulin levels compared with the LoMF groups. It has been reported that an increase in insulin levels may reduce lipolysis and promote fat storage by inhibiting lipase activity (30). Second, although obesity and hyperinsulinemia may lead to chronic activation of the sympathetic nervous system (31,32), the responsiveness of adipose tissue to sympathetic stimulation is reduced, resulting in an inhibition of fat loss in these individuals (30). An important finding of the current study was that self-perceived QoL for individuals with HiMF appears to be related to muscle strength and the capacity to perform ADLs rather than to body fat levels. A potential limitation of the study is the possibility for sex bias between HiMF (male-to-female ratio 20:10) versus LoMF (male-to-female ratio 8:17) groups.

In summary, resistance training increased muscle strength and the capacity to perform ADLs in individuals with HiMF and LoMF for the metabolic syndrome. QoL improved for individuals with HiMF, and this was independent of changes to body fat content or aerobic power. In contrast, there were improvements in whole-body fat and aerobic power for the LoMFT group, in the absence of improvements to QoL. Longer resistance training regimens or switching to aerobic training might increase this measure in individuals with LoMF.

Table 3—*Effect of resistance training on aerobic power, the capacity to perform ADLs, total muscle strength, and QoL of individuals with LoMF and HiMF*

Variable and group	Before	After	*P* group × time interaction
$\dot{V}O_{2peak}$ (ml · kg^{-1} · min^{-1})			
LoMFC	23.4 ± 3.8	22.5 ± 3.4	0.02
LoMFT	24.1 ± 7.7	25.8 ± 7.6*	
HiMFC	22.8 ± 4.2	23.2 ± 4.9	0.56
HiMFT	23.2 ± 6.5	24.1 ± 6.1	
Total PPT (s)†			
LoMFC	26.8 ± 3.6	27.1 ± 4.3	<0.01
LoMFT	28.4 ± 5.0	26.1 ± 4.7*	
HiMFC	25.7 ± 3.8	25.3 ± 4.1	<0.01
HiMFT	28.3 ± 6.1	25.8 ± 5.1*	
Total strength (kg)			
LoMFC	376.1 ± 136.5	371.7 ± 143.4	<0.01
LoMFT	378.6 ± 135.4	496.3 ± 137.3*	
HiMFC	535.4 ± 150.8	530.9 ± 153.5	<0.01
HiMFT	468.8 ± 133.7	628.1 ± 172.9*	
Self-perceived physical health			
LoMFC	74.8 ± 14.3	75.2 ± 17.3	0.99
LoMFT	82.5 ± 12.3	82.8 ± 11.5	
HiMFC	82.9 ± 10.9	79.1 ± 17.1	0.01
HiMFT	68.2 ± 17.7	78.3 ± 10.9*	
Self-perceived mental health			
LoMFC	74.46 ± 12.8	74.0 ± 20.5	0.60
LoMFT	81.4 ± 16.3	84.1 ± 9.6	
HiMFC	83.5 ± 11.8	77.8 ± 18.4	0.03
HiMFT	73.7 ± 12.8	80.4 ± 10.7	
Total strength (kg)‡			
LoMFC	376.1 ± 136.5	371.7 ± 143.4	<0.01
LoMFT	378.6 ± 135.4	496.3 ± 137.3*	
HiMFC	535.4 ± 150.8	530.9 ± 153.5	<0.01
HiMFT	468.8 ± 133.7	628.1 ± 172.9*	

Data are means ± SD. *P* group × time interactions represent changes between before and after intervention levels for the training groups compared with the control groups, for each group, HiMF and LoMF, analyzed separately. *$P \leq 0.05$ between before and after within each group. †Lower time on the PPT indicates better performance. ‡Total strength is the sum of seven exercises.

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