SUMMARY

EXCESS BODYWEIGHT, SPECIFICALLY EXCESS FAT WEIGHT, INCREASES THE RISK OF CHRONIC DISEASE AND PREMATURE DEATH. INCREASED PHYSICAL ACTIVITY/EXERCISE IS A RECOMMENDED STRATEGY FOR THOSE SEEKING TO EFFECTIVELY REDUCE AND MANAGE BODYWEIGHT. TRADITIONALLY, WEIGHT MANAGEMENT EXERCISE RECOMMENDATIONS HAVE FOCUSED ON AEROBIC-TYPE ACTIVITIES, SUCH AS WALKING, BIKING, SWIMMING, AND THE LIKE, WHICH TEND TO RESULT IN A SIGNIFICANT CALORIC EXPENDITURE DURING THE EXERCISE SESSION. STUDIES SUGGEST THAT RESISTANCE EXERCISE CAN ALSO PLAY AN IMPORTANT ROLE IN A LONG-TERM WEIGHT MANAGEMENT PROGRAM, ALBEIT THROUGH DIFFERENT MECHANISMS. THIS ARTICLE EXPLORES CURRENT ACTIVITY/EXERCISE RECOMMENDATIONS FOR WEIGHT LOSS/MANAGEMENT AND DISCUSSES THE POTENTIAL ROLE OF RESISTANCE EXERCISE.

INCEIDENCE AND IMPACT OF BEING OVERWEIGHT AND OBESE

Currently, in the United States, 69% of adults are overweight (body mass index [BMI] ≥ 25 kg/m²), whereas 36% meet the criteria for obesity (BMI ≥ 30 kg/m²) (13). After several decades of rapid increase, recent data suggest that we may be seeing at least a temporary plateau in obesity rates (13). Although this plateau is encouraging, efforts to reduce the current rates of the overweight and obese must remain a top public health priority. A nationwide plan focused on health promotion and disease prevention, Healthy People 2020, has established several objectives related to the reduction of the overweight and obese (21). According to the Healthy People 2020 document, the overweight and obese are associated with an increased risk of chronic disease and premature death (21). Chronic conditions associated with being overweight and obese include, but are not limited to, hypertension, type 2 diabetes, hyperlipidemia, heart disease, stroke, various types of cancer, osteoarthritis, respiratory problems, and gallbladder disease (2,12,21). The precise relationship between excess bodyweight and all-cause mortality is somewhat controversial. Although some studies have reported that adult all-cause mortality rates increase in concert with the increasing levels of the overweight and obese (1,5), Flegal et al. (14,15) reported no excess mortality associated with being overweight (BMI of 25–29.9 kg/m²). These studies are in agreement with the elevated mortality risk associated with obesity (BMI ≥ 30 kg/m²). Moreover, this excess mortality risk is exacerbated with increasing levels of obesity.

As further evidence of the seriousness of this issue, poor nutrition and a lack of physical activity (PA), often precursors of obesity, have been cited as the second leading “actual cause of death” in the United States, right behind tobacco usage, mainly cigarette smoking and exposure to second-hand smoke (28). The economic impact of being overweight and obese in the United States is staggering, estimated at more than $215 billion annually, with $147 billion in direct medical cost (18).

KEY WORDS: obesity; weight management; aerobic exercise; resistance exercise; excess postexercise oxygen consumption
Exercise and Obesity: Where Does Resistance Exercise Fit in?

**MANAGEMENT OF THE OVERWEIGHT AND OBESE**

Clearly, there are a significant number of Americans who are currently above the recommended BMI range of 18.5-24.9 kg/m² (13). Although a considerable number of adult’s report that they are trying to lose weight, few are making the necessary lifestyle changes required to promote weight loss (3). Furthermore, among those individuals who have lost at least 10% of their bodyweight, 8 of 10 are unable to maintain the weight loss for 1 year (40). The current clinical recommendations suggest an initial weight loss goal of 10% of bodyweight over the course of 6 months and define successful weight maintenance as “a weight regain of <3 kg in 2 years and a sustained reduction in waist circumference of at least 4 cm” (7).

When considering lifestyle approaches to weight loss and weight management, the American College of Sports Medicine (ACSM), the National Heart, Lung, and Blood Institute in cooperation with the National Institute of Diabetes and Digestive and Kidney Diseases, and the Obesity Society all recommend that attention be directed toward the following 3 component areas (7,24):

1. Diet—a reduction in daily caloric intake. Specifically, a reduction in foods and beverages that tend to be high in fat or simple sugars but are often lacking in essential nutrients. Examples include snack foods items like chips, sodas, candy, desserts and, of course, the ever-convenient “fast-food” fare.
2. Physical activity/exercise—To compound the problem of excess caloric intake through the overconsumption of high-fat/high-calorie foods, most Americans expend too few calories through PA. Less than 45% of adults are currently meeting minimal PA recommendations, with 36% reporting no leisure-time PA at all (21).
3. Behavior modification—This component area has to do with identifying behaviors associated with or contributing to poor dietary choices and a sedentary lifestyle and then implementing strategies that lead to favorable changes in these behaviors. Environmental challenges that make PA more difficult (decreasing emphasis on physical education in the schools, lack of safe areas to walk/bike, poor air quality, etc.) and poor nutritional choices (abundance of fast-food restaurants, high-calorie “convenience” snacks and drinks, lack of fresh fruits and vegetables in many intercity neighborhoods etc.) must be overcome for the successful long-term management of bodyweight.

This comprehensive lifestyle approach to weight loss/weight management affords individuals with the best opportunity for successful long-term weight loss success.

While recognizing the essential importance of diet and behavior modification, the focus of this article is to examine the role of PA/exercise in assisting with weight loss/weight management. Specifically, we will review the current recommendations concerning traditional aerobic-type PA (walking, biking, swimming, etc.) for the purpose of weight loss/weight management and then examine the potential role of resistance exercise (RE) as part of a comprehensive weight management strategy.

**PHYSICAL ACTIVITY AND HEALTH**

In 1995, the Centers for Disease Control and the ACSM jointly released their landmark recommendations on PA and health, encouraging “30 minutes or more of moderately intense PA on most, preferably all, days of the week” (31). This recommendation was later endorsed in the 1996 release of Physical Activity and Health: A Report of the Surgeon General and the 2000 release of Healthy People 2010 (36,37). The health benefits associated with regular PA include reduced risk of coronary heart disease, hypertension, weight gain, type 2 diabetes, osteoporosis, colon and breast cancer, anxiety and depression, and overall mortality (6,33,37). In addition, regular PA can enhance both physical and cognitive function in older adults (33).

In 2007, the ACSM and the American Heart Association issued an update and clarification of the original 1995 recommendations (19). Any confusion as to the recommended minimal frequency of weekly bouts of PA was clarified in the updated release. The goal is to “accumulate” a minimum of 30 minutes of moderate-intensity (3–6 metabolic equivalents) PA throughout the course of the day, at least 5 d/wk, for a weekly total of at least 150 minutes. The fact that 30 minutes can be “accumulated” (bouts of 10 minutes or more) over the course of the day truly makes it a realistic and achievable goal for most adults. Additionally, those capable of safely engaging in vigorous (>6 metabolic equivalents) PA may derive similar health benefits with fewer and shorter sessions (19). The focus of both the original and updated recommendations is on the quantity and quality of mainly aerobic-type PA/exercise, associated with improved health and reduced risk of chronic disease. Individuals who exceed the minimal goals are likely to experience even greater improvements in health, indicating a dose-response relationship (19). Similar recommendations on PA and health were subsequently presented in the 2008 Physical Activity Guidelines for Americans (32), Healthy People 2020 (21), and the 2011 ACSM position stand on exercise for “apparently healthy adults” (16). In addition, recent initiatives such as “Let’s Move” (27) and “NFL Play 60” (29) have sought to promote health and prevent obesity in children by encouraging 60 minutes of moderate-to-vigorous PA each day. Table 1 provides the summary of key documents on PA and health.

**PHYSICAL ACTIVITY FOR WEIGHT MANAGEMENT**

In 2001, ACSM released its position stand titled Appropriate Intervention Strategies for Weight Loss and Prevention of Weight Regain for Adults (24). An updated version of this position stand was released in 2009 (10). Although...
<table>
<thead>
<tr>
<th>Year released and title</th>
<th>Issuing organization</th>
<th>Aerobic activity recommendations/conclusions</th>
<th>Resistance exercise recommendations/conclusions</th>
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</thead>
<tbody>
<tr>
<td>1995: Physical activity and public health. A recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine (31)</td>
<td>ACSM and Centers for Disease Control</td>
<td>≥30 minutes of “accumulated” moderate-intensity PA performed most, preferably all, days of the week</td>
<td>Acknowledged as being beneficial but no specific recommendations presented</td>
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<td></td>
<td>Increased intensity or duration will likely result in greater health benefits</td>
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<tr>
<td>2000: Healthy People 2010 (37)</td>
<td>US Department of Health and Human Services</td>
<td>Aerobic PA goals consistent with the 1995 ACSM/Centers for Disease Control recommendation</td>
<td>≥2 d/wk</td>
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<td>Additional goals for vigorous activity: ≥3 d/wk, ≥20 min/d</td>
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<tr>
<td>2007: Physical activity and public health updated recommendations for adults from the American College of Sports Medicine and the American Heart Association (17)</td>
<td>ACSM and American Heart Association</td>
<td>≥30 minutes of “accumulated” (bouts of 10 min or more) moderate-intensity PA 5 d/wk</td>
<td>≥2 nonconsecutive days each week, 8–10 exercises addressing the major muscle groups, 8–12 repetitions to a point of volitional fatigue</td>
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<td>OR</td>
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<td>Vigorous activity 20 min/d 3 d/wk</td>
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<td>Various combinations of moderate- and vigorous-intensity PAs</td>
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<td></td>
<td></td>
<td>Exceeding the above levels will provide even greater health benefits</td>
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(continued)
| 2008: 2008 Physical Activity Guidelines for Americans (32) | US Department of Health and Human Services | ≥150 minutes of moderate-intensity PA/wk (accumulated in bouts of 10 minutes or more) | ≥2 d/wk, exercises addressing the major muscle groups, 8–12 repetitions, moderate to high intensity |
| 2010: Healthy People 2020 (21) | US Department of Health and Human Services | Aerobic PA goals consistent with the 2008 Physical Activity Guidelines for Americans | Resistance exercise goals consistent with the 2008 Physical Activity Guidelines for Americans |
| 2011: Quantity and Quality of Exercise for Developing and Maintaining Cardiorespiratory, Musculoskeletal, and Neuromotor Fitness in Apparently Healthy Adults: Guidance for Prescribing Exercise (16) | ACSM | Moderate-intensity aerobic activity (3–5.9 metabolic equivalents) for ≥30 min/d on ≥5 d/wk for a total of ≥150 min/wk | 2–3 d/wk addressing each of the major muscle groups. Also included were recommendations for inclusion of exercises to improve flexibility, agility, balance, and coordination on ≥2 d/wk |

| OR | OR |
| Various combinations of moderate- and vigorous-intensity PAs | Exceeding the above levels will provide even greater health benefits |

| OR | OR |
| Vigorous aerobic activity (≥6 METs) for ≥20 min/d on ≥3 d/wk (≥75 min/wk) |  

| OR | Various combinations of moderate- and vigorous-intensity PAs |

ACSM = American College of Sports Medicine; PA = physical activity.
consistent with the original position stand the recent update provides clear and concise PA recommendations based on the particular weight management goal (prevention of weight gain, weight loss, or maintenance of weight loss). These recommendations are summarized below:

- 150–250 min/wk of moderate-intensity PA will help protect against initial weight gain.
- >250 min/wk of moderate-intensity PA can result in a “clinically significant” weight loss.
- For improved maintenance of weight loss, 250–300 min/wk of moderate-intensity PA is recommended ("approximately 2,000 kcal/wk").

This position stand article clearly indicates that although the public health recommendation of 150 min/wk of moderately intense PA may provide important health benefits and assist in weight control, a greater amount of PA is necessary for weight loss and successful long-term weight management. In 2002, the Institute of Medicine recommended the accumulation of 60 min/d of moderately intense PA to optimize weight management (23). This level of PA is consistent with that reported by the National Weight Control Registry whose members have successfully maintained a weight loss of at least 30 pounds, for more than 5 years (40). In a recent study, Lee et al. (26) reported that over a 13-year follow-up period of 34,000 women, those who were most successful in preventing weight gain were averaging 60 minutes of moderate-intense PA per day. In their systematic review, Curioni and Lourenco (8) concluded that the combination of exercise and diet results in greater weight loss and better success with weight loss maintenance than diet alone. However, the difficulty of maintaining weight-loss is evident in the finding that both diet plus exercise and diet alone groups regain approximately half of their weight in 1 year (8).

In preparation for the release of the 2008 Physical Activity Guidelines for Americans (32), the Physical Activity Guidelines Advisory Committee Report, 2008, was released (33). This comprehensive document examined the evidence-based health benefits of PA, including the role that PA plays in weight management. Based on an extensive review of the literature, the Advisory Committee Report concluded that 150 min/wk of moderate-intensity activity ("walking at a 4 mile/h pace") or 75 minutes of more intense PA ("jogging at a 6 mile/h pace") will help prevent initial weight gain, and when coupled with dietary modification, it can assist with weight loss. To prevent weight regain in individuals who have previously lost weight, the PA requirement is significantly greater. The suggested volume of exercise to prevent weight regain ranged from 26 minutes per day when jogging at a 6 mile per hour pace to 80 minutes per day when walking at a 3 mile per hour pace (33).

These intensity-dependent duration goals seek to assure similar weight management benefits, despite variations in exercise intensity. This is in keeping with the previously mentioned recommendations for PA and health (19), although the volume of PA required for optimizing weight management success is clearly greater than that necessary for improving health. Table 2 provides the summary of key documents on PA and weight management.

**RESISTANCE EXERCISE FOR WEIGHT MANAGEMENT**

RE is typically performed for the purpose of increasing strength or muscle mass or both (20). In addition to improvements in strength and muscle mass, RE also leads to favorable changes in the areas of body composition, muscular endurance, bone density, cardiac risk factors, psychosocial well-being, and metabolism (4,7,20,35–37,39). In their extensive review article, Strasser and Schobersberger concluded that RE results in favorable changes in body composition (decreased fat mass and increased lean body mass [LBM]), can help "maintain reduced fat mass in obese patients after exercise training or energy intake restriction," and is effective in reducing abdominal obesity (35). Common modes of RE include the use of barbells/dumbbells, resistive bands/tubing, strength training machines, and various bodyweight exercises. Public health recommendations on PA and health encourage the inclusion of regular strength training activities (7,16,19,21,33).

Despite the significant health and functional benefits that RE can provide, it is not an effective sole strategy for reducing excess bodyweight. Furthermore, the combination of RE and a reduced calorie diet does not provide additional weight loss benefits beyond that seen with diet alone (10). This should by no means discourage the use of RE as part of a weight loss/weight management plan. Although the inclusion of RE might not enhance short-term weight loss, it does result in healthy changes in body composition (decreased fat mass and increased LBM) and may play an important role in successful long-term weight management.

A notable study by Kirk et al. (25) illustrated the potential weight management value of brief but intense RE sessions. In this 6-month study, young overweight adults engaged in 3 RE sessions per week completing 1 set of 9 different exercises using loads equivalent to 85–90% of the 1 repetition maximum. The heavy loading limited the number of completed repetitions to 3–6 for each exercise. The average amount of time required to complete each workout session was approximately 11 minutes. Upper-body and lower-body strength in the resistance-trained group increased by approximately 50% and fat-free mass (FFM) increased by 2.7%. The resistance-trained subjects experienced a significant increase in both resting metabolic rate (RMR) and sleep metabolic rate (SMR) when compared with control subjects. Additionally, there was an encouraging increase in 24-hour energy expenditure (EE) and a decrease in the resting and sleep respiratory quotient (RQ) values in the resistance-trained group. This decrease in RQ suggests a greater reliance on fat as a fuel source. The changes seen in RMR, SMR,
### Table 2

<table>
<thead>
<tr>
<th>Year released and title</th>
<th>Issuing organization</th>
<th>Aerobic activity recommendations/conclusions</th>
<th>RE recommendations/conclusions</th>
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</thead>
<tbody>
<tr>
<td>1998: Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults – The Evidence Report (7)</td>
<td>National Heart, Lung, and Blood Institute, in cooperation with the National Institute of Diabetes and Digestive and Kidney Diseases</td>
<td>An initial goal of 30–45 minutes of moderate-intensity PA 3–5 d/wk, with a long-term goal of ≥30 min/d on most, preferably all days of the week</td>
<td>None</td>
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<tr>
<td>Also adopted by the North American Association for the Study of Obesity now known as The Obesity Society</td>
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<tr>
<td>2001: ACSM position stand Appropriate Intervention Strategies for Weight Loss and Prevention of Weight Regain for Adults (24)</td>
<td>ACSM</td>
<td>Overweight and obese adults should progress toward an initial goal of at least 150 min/wk and should eventually progress to 200–300 min/wk or ≥2,000 kcal/wk of leisure time PA</td>
<td>No specific recommendations based on the lack of evidence that the addition of RE provides any additional weight loss benefit over and above that of diet alone or combined diet and aerobic activity</td>
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<tr>
<td>The strength enhancing and functional benefits of RE were acknowledged</td>
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</table>
| 2008: Physical Activity Guidelines Advisory Committee Report (33) | US Department of Health and Human Services | Conclusions were based on the particular weight management goal and the intensity of the activity:  
- To prevent initial weight gain: walking at a 4 mile per hour pace (moderate) for 150 min/ wk or jogging at a 6 mile per hour pace (vigorous) for 75 min/wk  
- To promote weight loss: 150–300 min/wk  
- To prevent weight regain: walking 80 min/d at a 3 mile per hour pace OR 54 min/d at a 4 mile per hour pace OR jogging 26 min/d at a 6 mile per hour pace | No specific recommendations related to weight management |
| Based on its review of the literature the committee report concluded that RE did not have a significant impact on weight loss or fat loss, although it could contribute to favorable changes in body composition via increases in fat-free mass |
and 4-hour Ewre based on oxygen consumption values obtained 72 hours after exercise using a room calorimeter and appeared to be a function of the increase in FFM. Although the aim of this study was not to induce weight loss, the findings offer compelling support for the inclusion of RE as part of a weight management strategy. Specifically, the potential role of high intensity, low volume RE as part of a comprehensive weight management program. Although Kirk et al. (25) did not examine the impact of exercise-induced excess post-exercise oxygen consumption (EPOC) in their study, Schuenke et al. (34) have demonstrated that high-intensity RE results in EPOC for periods of up to 38 hours after exercise, whereas Heden et al. (22) have reported elevations in EPOC and EE (approximately 100 kcals/24 h) for up to 72 hours. Thus, a RE-induced EPOC could further amplify the beneficial impact on weight management. Encouraging reports on the value of RE when combined with a reduced calorie diet have been reported in the literature (4,11,17). Of significant importance was the finding that during periods of reduced calorie intake, RE in combination with aerobic exercise can facilitate the loss of fat mass beyond that seen with RE alone.

Table 2 (continued)

<table>
<thead>
<tr>
<th>2009: ACSM position stand</th>
<th>ACSM</th>
<th>250–300 min/wk for weight loss maintenance (approximately 2,000 kcal/wk)</th>
</tr>
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<tbody>
<tr>
<td>Appropriate Physical Activity Intervention Strategies for Weight Loss and Prevention of Weight Regain for Adults (10)</td>
<td>Moderate-intensity PA:</td>
<td>No specific recommendations based on the lack of evidence that the addition of RE provides any additional weight loss benefit over and above that of diet alone or combined diet and aerobic activity</td>
</tr>
<tr>
<td></td>
<td>150–250 min/wk to help prevent initial weight gain</td>
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<td>&gt;250 min/wk for weight loss</td>
<td>RE increases fat-free mass both when used alone and in combination with a diet-induced weight loss program</td>
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</table>

ACSM = American College of Sports Medicine; PA = physical activity; RE = resistance exercise.
approximately 4.5 kcal/d. Therefore, RE to protect against the loss of muscle tissue and thus better preserve RMR would appear to be an important strategy for long-term weight management.

Bryner et al. (4) reported that in a 12-week study, RMR was preserved in subjects who consumed a very low-calorie diet (VLCD) and engaged in a 3 d/wk RE program (10 exercises, 2–4 sets, 8–15 repetitions). This preservation of RMR was not seen in subjects who consumed a VLCD in combination with 4 d/wk of aerobic exercise (20–60 minutes of walking, biking, or stair climbing) (4). However, in an 8-week study, Geliebter et al. (17) reported similar decreases in RMR in subjects on a reduced calorie diet and performing RE (8 exercises, 3 sets, 6–8 repetitions) versus those on a reduced calorie diet and performing aerobic exercise. The shorter study duration and lower training volume may help explain the failure of RE to preserve RMR in the RE group in this study compared with the findings of Bryner et al. (4). The ability of RE to protect against declines in RMR during weight loss requires further investigation.

The adaptive responses commonly observed with aerobic exercise (increased \( \text{VO}_{2\max} \) and decreased fat mass) and those typical of RE (increased LBM, increased strength, and increased RMR) have been reported in exercise studies that combined these 2 modes of exercise (9,30). When compared with aerobic only (9, 30) or resistance only (9), the combined training was superior in terms of its effects on percent body fat (9) and the reduction of fat mass (9,30). These studies suggest that perhaps the best exercise program for both health and weight management is one that combines these 2 modes of exercise.

Although further studies are necessary, there is credible evidence to suggest that RE can play an important role in a comprehensive weight management program. The potential for RE to reduce, or perhaps even prevent the decreases in RMR and FFM that often accompany weight loss programs that are based solely on diet or diet plus aerobic exercise, is intriguing and merits further investigation. Studies using various levels of caloric restriction and incorporating a variety of combined aerobic and RE protocols might yield further insight as to the “optimal” exercise approach to weight loss/weight management.

CONCLUSIONS

1. More than two-thirds of American adults are overweight or obese and are at an increased risk for chronic disease and premature death. In addition to the human toll, the overweight and obese represent a huge economic burden to society.

2. Aerobic-type PA is associated with a wide variety of health benefits and is recognized as a critical component of a comprehensive weight loss/weight management program.

3. For the purpose of optimizing weight management, adults should be encouraged to work toward a goal of 60 min/d of moderate-intensity PA that is mainly aerobic in nature. Individuals who can safely engage in more vigorous PA can derive similar weight management benefits in less than 60 min/d.

4. RE promotes improvements in muscle mass and strength in addition to providing other valuable health benefits. Current recommendations on PA and health encourage the inclusion of RE.

5. Programs that include both aerobic and RE can provide all the healthful benefits of each of these very different types of exercise and may be superior in terms of producing favorable changes in body composition.

6. A weight management strategy that combines a reduced calorie diet, aerobic exercise, and RE may be the best combination for reducing unhealthy body fat while attenuating the losses in LBM and RMR that commonly occur during periods of weight loss. Further study is required to determine how best to incorporate RE into a comprehensive weight loss/weight management program.


