Weight Management
WM™
Newsletter
Fall 2004
Volume 2, Number 2

Resting energy expenditure: implications for weight management

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Overweight and obesity, despite having multifactorial origins (e.g., environmental, behavioral, genetic), are ultimately caused by a chronic energy imbalance resulting in weight gain. Clearly in order to lose weight (and maintain a lowered body weight) a lower net energy balance must be achieved, by consistently eating fewer (and/or burning off more) calories. This article will focus on commonly misunderstood issues, related to energy metabolism, that are barriers to effectively facilitating weight loss. By understanding the documented (versus purported) effects of energy restriction, physical activity, hypothyroidism, and skeletal muscle changes on resting energy expenditure (REE) dietetics professionals can better help their clients focus on activities that produce an energy balance deficit and result in weight loss.

Energy expenditure

Total energy expenditure (TEE), measured over 24 hours, consists of REE, physical activity-induced energy expenditure, thermic effect of food, facultative thermogenesis, and anabolism/growth (1). REE, the largest component of TEE (about 65%–75%), consists of involuntary activities necessary to sustain life, e.g., circulation, respiration, hormone secretion and nerve activity. In research settings REE is measured in the morning (after ≥ 12-hour fast and ≥ 12-hour abstinence from exercise) in a thermoneutral room (26 to 29° C) while the subject is supine and resting.

Is there a benefit to measuring REE?

HealtheTech and Korr Medical have developed devices to measure REE that are relatively inexpensive and easy to use. HealtheTech (www.healthetech. com) makes the BodyGem® and MedGem® indirect calorimetry devices, which are small handheld devices that have been determined to accurately measure REE (2). The MedGem® is Food and Drug Administration (FDA) approved, and has ICD9 reimbursement codes associated with it. HealtheTech currently sells "measurements" rather than devices. The devices are preloaded with either 20 or 100 measurements, and cost $419 to $1,899 for the measurement set, which includes disposable mouthpieces and nose clips. When the preloaded measurements have been used up, more can be purchased (by sending the device back to HealtheTech to be "reloaded"). Typical charges for measuring REE range from $45 to $100 per measurement.

Korr Medical (www.korr.com), the same company that makes hospital

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metabolic carts, has several REE devices that are designed for clinics or private practice professionals. Their REEVUE™ device is FDA approved and also has ICD9 codes. REEVUE™ costs $3,500; in this case you are buying the device outright (not just preloaded measurements), so when it's paid for your costs decrease. Disposable mouthpieces are additional and run $5 to $9 each.

A variety of factors can affect measured REE, including stress or anxiety, diurnal variation, thermic effect of food, elevated post-exercise oxygen consumption, sickness, stimulants, and certain medications. Measuring REE under standardized conditions typically results in small variations (usually < 3%) (3). Recent research showed that measurement of REE conducted in the afternoon (after a four-hour fast and 12-hours post exercise) averaged 100 kcal. more (about 6%) than REE evaluated under standard conditions mentioned above. The authors concluded that REE measured in the afternoon can be assumed to be about 100 kcal. higher than a morning measurement (4).

Thus, since it is relatively easy to measure REE, the question is no longer how but why? Prediction equations, such as the Harris-Benedict equation, do not predict REE with accuracy for all clients (See energy requirement equation article on page 9). Measuring REE is likely to most benefit clients who have an actual REE that is greater than ±10% of predicted REE.

However, it is not possible to determine which clients will fall outside of this range without measuring REE. Knowing the individual's REE provides the most valid basis for determining energy intakes at desired levels of energy deficit. In addition, showing clients their actual REE may serve to expedite addressing underreported energy intake, enabling dietetics professionals to move forward with helping clients problem-solve the challenges that lie ahead on the path to lifestyle change.

How does energy restriction affect REE?

For subjects on low-calorie diets (LCDs) of around 1,200 kcal./day, the reduction in REE (if any) is modest (< 5%). Conversely, a 5% to 15% reduction can be seen with very low calorie diets (VLCDs), which by definition are < 800 kcal./day (5). However, many subjects enrolled in VLCD programs may consume around 1,200 to 1,600 kcal./day. According to a review paper recently published by Poehlman, data on REE changes are inconclusive. The REE doesn't always drop with energy restriction. However, "The trend is that the greater the (magnitude of) energy restriction, the greater the potential reduction in REE" (6).

A REE reduction greater than 15% has also been reported in the literature, however these are typically seen in older studies that have used a ratio method to adjust the follow-up REE. The ratio method adjusts the follow-up REE to eliminate the confounding effects of changes in body weight, fat-free mass (FFM), and fat mass on a follow-up REE. However, the ratio method can make the follow-up REE appear falsely lower than it actually is as it assumes a linear relationship between fat and FFM.

Newer studies use an analysis of covariance, which is appropriate methodology for the curvilinear relationship between REE and FFM (4). Additionally, some studies have not included an appropriate time between weight loss and the follow-up REE measurement. It takes about seven to 14 days to normalize REE once a person is started on maintenance-level calories. If the follow-up REE is measured too soon, the follow-up REE will likely appear falsely low (7).

The suppression in REE, secondary to energy restriction, is believed to be due to several factors including the suppression of both active thyroid hormone (T3) and sympathetic nervous system (SNS), in addition to changes in insulin, glucagon, growth hormone and glucocorticoids. It may be the normalization of these hormonal changes (secondary to maintenance-level calorie intake), which leads to the normalization of REE.

These data are helpful for a couple of reasons. First, most clients are consuming ≥ 1,200 kcal./day, and so REE would be only modestly altered (about 5%) if at all. Remember that the magnitude of energy restriction is the key factor. The observed effects on REE secondary to energy restriction have been overstated by the so-called "starvation response" (metabolic adaptation). Research attempting to document a "starvation response" in chronically underfed populations has lead researchers to conclude that it is of "doubtful existence." It is postulated that any major energy conservation comes from a reduction in TEE, through a reduction in activities of daily living (3).

How does yo-yo dieting affect REE?

Many clients, struggling to lose weight, strongly believe that they have a "low metabolism" secondary to yo-yo dieting. This theory, that cycles of energy restriction followed by weight gain ultimately lower REE, is not supported by careful data review. Several comprehensive reviews concluded that weight cycling does not have a negative effect on REE or FFM indicating that from a physiological standpoint, previous weight loss attempts do not make future attempts more difficult (8–10). However, a client's belief that he or she has a low metabolism may generate an unnecessary expectation of failure—which if not addressed may become a self-fulfilling prophecy.

How does physical activity affect REE?

Physical activity does have the ability to offset the potential reduction in REE secondary to energy restriction. However, the effect of physical activity is not uniform; physical activity doesn't increase REE in all subjects. This is likely due to the fact that lower-intensity activities have no effect on REE; only moderate- to high-intensity activities have the potential to offset reductions in REE (secondary to post-exercise oxygen consumption). The general trend is that the higher the intensity of physical activity, the greater the potential increase in REE (6) .

Does adding muscle increase REE in a clinically significant way?

It is often suggested that skeletal muscle has a high REE: This is incorrect. While skeletal muscle contributes 30%–40% of total body weight, its contribution to REE is considerably smaller than that of organs (see Table 1). The REE of skeletal muscle is 13 kcal./kg./day, adipose tissue is 4.5 kcal/kg/day, while organs (heart, kidneys, liver and brain) have the highest REE (200 to 400 kcal./kg./day) (11).

It is also a commonly held assumption that increasing skeletal muscle mass significantly increases REE. This is not supported by well-conducted studies: A meta-analysis of 22 studies found "no relationship between changes in REE and changes in FFM across studies"(12). This is not surprising because if a client replaced 1 kg. of adipose tissue (4.5 kcal./kg.) with 1 kg. of skeletal muscle (13 kcal./kg.), the net increase in REE would only be about 9 kcal./kg. Typical activity patterns of overweight clients are often well below the level necessary to achieve even a 1 kg. increase in skeletal muscle.

How does hypothyroidism impact REE?

Untreated hypothyroidism appears to lower REE by 30 ± 10%, while subclinical hypothyroidism is estimated to lower REE by 15 ± 5% (13–15). Approximately 7.5% and 10% of the population has either subclinical or frank hypothyroidism respectively, with the majority of cases (about 80%) occurring in females. About 40% of treated hypothyroid cases may not be properly controlled, and may still exhibit symptoms of hypothyroidism (e.g., low body temperature, dry skin, hair loss, depression, low REE)(16).

Using REE knowledge to better facilitate weight loss

For most people, changes in energy intake, yo-yo dieting, physical activity, and body composition are not likely to contribute significantly to changes in REE. From a practical standpoint, underreporting energy intake and overreporting physical activity is likely to be more problematic. It is not unusual for a weight-management client to report consuming about 1,000 to 1,200 kcal./day. However, carefully controlled metabolic studies show a discrepancy between self-reported and actual intakes among overweight subjects (17–18). While most subjects underreport energy intake, underreporting generally increases as body mass index increases (19) and overweight/obese subjects may have intakes approximately 40% higher than reported (18). Reasons for underreporting energy intakes may include inaccurate portion assessment, incomplete recall, psychosocial motivation, and perhaps the unconscious process of denial (17).

Underreporting energy intake represents a significant challenge for dietetics professionals attempting to facilitate weight loss in their clients. If the fallacy of underreported intake cannot be "confronted," the path forward is effectively blocked. Being confident in your REE knowledge supports dietetics professionals in addressing underreporting of energy intake.

Regardless of whether REE is measured or estimated, by understanding the role of REE in weight management, dietetics professionals will be able to better help their clients to focus their efforts on activities that lower energy balance and ultimately improve weight management outcomes. Since REE doesn't change except in extreme cases, dietetics professionals need to redouble their efforts to encourage and support behavioral changes in diet and physical activity.

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Table 1. Lean body mass contribution to REE (11)

	% body weight	% REE
Organs	5%–6%	60%–70%
Skeletal muscle	30%–40%	16%–22%

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From the editor

Helen M. Seagle, MS, RD, is the 2004-2005 Weight Management DPG communications chair.

In the very first issue of this newsletter (summer 2003), I proposed that *Weight Management Newsletter* was a name that needed to be improved. I put a call out to members to submit a more exciting name for what I hope will be viewed as an exciting newsletter. You all responded (thank you!) with an amazing list of names, ranging from cute to verbose, but there was no clear winner. Unfortunately no one name resonated with the work we, as a dietetics practice group, intend to do through this newsletter. The problem might be that we have not yet created our identity or our niche. Proposed names represented an individual's perspective rather than the collective view of what the newsletter could attain. So, I have decided that we need to postpone assuming a new name until we have truly developed our identity. (Besides, the Executive Committee got sick of me submitting new names to vote on.) Of course, if the inspiration hits, please feel free to send me your ideas!

This issue brings you review articles about two intervention tools—very low-calorie diets and resting energy expenditure measurements. Both articles were sent out for peer review, at least twice, and both articles generated much reviewer comment about the utility of the tool and the positioning of the tool among weight-management interventions.

First, it is great that I have access to authors and reviewers who clearly have expertise, and more importantly a passion for weight management as well as a willingness to actively participate in the review process. Second, I realized that if the authors and reviewers have passion about these topics then readers would likely have input too. So I challenge you to not just read these articles and then lay them aside. Instead, I'd like you to participate more fully in the process of *attaining our highest level of professional practice in prevention and treatment of overweight and obesity* (1). Both topics deserve follow-up articles about how our members use these two tools. Are there best practices that we can share? Are there pitfalls worthy of mention? Are there still unanswered questions or barriers to implementation? Are there opportunities that we might be overlooking? I encourage you to send me your experiences and thoughts about both these topics so we can shape follow-up articles.

But don't stop there at those two articles: Do the other articles and columns promote the highest level of professional practice in the prevention and treatment of overweight and obesity? Any chance you will check out the www.eatright.org Web site for more information about the ADA method of evidence analysis or to sign up for the *On the Pulse* newsletter? Do you plan to join the Dietetics Practice Research Network? Have you re-evaluated your use of prediction equations? Please, at any time, feel free to let me know your thoughts about any item related to the newsletter; I encourage you to do so (communications@wmdpg.org).

On another note, this year at the Food & Nutrition Conference & Expo (FNCE), the prestigious Langholz Award was presented to a British husband and wife research team: Drs. Andrew and Anne Prentice. Although you may not be familiar with the name, Andrew Prentice has been a leader in the world of body-weight regulation: Undoubtedly you utilize his research findings in your every-day practice. I am very proud that our association has honored this industrious researcher. If you are interested in learning more about his work, check out his review article in the July 2004 issue of *Nutrition Reviews*.

And yes, this is the "fall" issue even though the calendar says it is "winter." Please forgive the tardiness and expect to see the REAL winter issue soon.

1. Excerpted from the Weight Management Dietetic Practice Group mission statement.

"I've come to think of membership in ADA as a bit like membership in a health club. To reap the benefits of being a member, you have to use the facilities, work out on the equipment, show up for the aerobics classes."

—Susan Laramee, MS RD, 2004-2005 ADA president

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