RESEARCH ARTICLE

A new approach to weight management counseling: Metabolic Factor in multiple populations

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Abstract

Background: Metabolic factor (MF) provides a standardized metric to compare resting metabolic rate (RMR) between populations and across time. Better understanding of one's metabolism may provide insight into the successes or failures of weight loss and weight management. Weight loss clients enjoy numbers to motivate success and continuation of positive lifestyle changes, and MF may be a useful tool to use that goes beyond the weight number on a scale. The purpose of this study was to explore the potential use of MF in clinical weight counseling by assessing MF in a variety of populations and determine if additional variables support previous MF findings.
Methods: RMR was measured via indirect calorimetry in sixty-seven adults $\geq$ 18 years old including athletes, non-athletes, general young and older adults. Anthropometric measurements included BMI, waist-to-hip ratio (WHR), and body composition (percent body fat).
Results: Athletes had a significantly higher MF compared to non-athletes (12.2 ± 1.9 vs 10.5 ± 2.4, p = .006) and older adults had a significantly lower MF compared to younger adults (8.7 ± 1.8 vs 11.4 ± 2.2, p < .0001). Significant correlations were found between MF and BMI (r = -.387, p =.001), age (r = -.433, p < .0001), percent body fat (r = -.515, p < .0001), and physical activity (r = .420, p < .0001), while no relationship was present between MF and WHR.
Conclusion: Previous MF research demonstrating lower MF with higher BMI was consistent in newly tested populations including athletes and older adults. New data suggests lower body composition and higher physical activity are also associated with higher MF. Metabolic factor may provide valuable insights for clinical weight counseling to assist with weight management and improving body acceptance.

1. Introduction

Resting metabolic rate (RMR) is the number of calories expended at rest per day and accounts for 50%-80% of total energy expenditure, while thermogenesis and physical activity comprise the remaining 20%-50%.[1] A person's RMR can be calculated using prediction equations or, more accurately, measured through indirect calorimetry. Indirect calorimetry measures the inspiratory volume of oxygen and the expiratory volume of carbon dioxide to estimate calories expended at rest. While this method is useful and accurate for assessing energy expenditure in a clinical or laboratory setting, the RMR for one subject cannot be easily and meaningfully compared to the RMR of another subject. Metabolic activity is influenced by many factors including gender, body composition, physical activity level, genetics, and age. Because of these factors, RMR values should be converted into a standardized metric before comparisons can be useful. Davis and colleagues formally identified a concept called metabolic factor (MF) as a way to standardize RMR values to allow for comparisons between populations and across time.[2] MF is calculated by dividing RMR by weight in pounds. Simply put, MF is the number of calories expended at rest per pound of body weight. Thus far, the data suggests that a high MF is favorable for weight loss and this metric is stable even following bariatric surgery, where individuals with a higher MF lost more weight after surgery than those with a lower MF.[3] MF is a promising new concept that could be useful in weight management and for enhancing overall understanding of metabolic activity. Because MF allows RMR to be standardized, it could be useful to explain why some individuals may be predisposed to certain weight categories, or body mass index (BMI). In a clinical setting, this may be particularly important for counseling on body acceptance and teaching patients the concept of "health at every size" (HAES®).[4]

Davis et al. compared the MF of normal weight, overweight, and obese subjects and discovered an inverse relationship between BMI and MF.[2] Individuals with a higher body weight and BMI had a lower MF. An additional study looked at the stability of MF in obese individuals before and after bariatric surgery. Between 9-19 months after bariatric surgery, the 18 subjects lost an average of 97 pounds and an average decrease in RMR from 2614 to 1954 kcals was observed.[3] While the weight loss ($p < .01$) and decrease in RMR ($p < .05$) were statistically significant, the average MF only increased from 8.1 to 8.6, which was not a significant change. These results indicate while measured weight and RMR values can fluctuate, MF may remain stable. This finding is important because it suggests that metabolic factor may be a stable characteristic and thus could be useful to improve clinical weight management counseling.

Davis and colleagues were the first to report such findings on MF. Before a concept that has such novel implications for clinical practice can be adopted, replication of the findings is warranted. Therefore, the purpose of this study was twofold: first, to test the original findings by Davis et al. in order to explore the potential use of MF in clinical weight counseling[2], and secondly, to expand upon previous findings and measure MF in additional populations to explore other variables that may be associated with MF. The two additional populations investigated in the current study included athletes and older adults. It was hypothesized that individuals with a higher BMI would present with a lower MF across both tested populations, a replication of previous findings.[2] Other variables investigated included waist-to-hip ratio, percent body fat, sleep, physical activity, and health history. It was hypothesized that as MF decreased, waist-to-hip ratio, number of healthy history events, and percent body fat would increase; and as MF increased, sleep and physical activity level would also increase.

2. Methods

2.1 Participants This study included 67 participants varying from college students, faculty, and staff, adults in the local community, and older adults in a nearby retirement community. All were recruited by email, flyers, and word of mouth. Individuals were excluded from the study if they were under 18 years old, on any medication known to alter metabolism, or had any history of an uncontrolled thyroid disease. The study was approved by the Institutional Review Board on campus and all participants provided written informed consent.

2.2 Testing Procedures Before the day of testing, subjects filled out a pre-participation questionnaire and self-reported data was collected including general demographics, personal and family health history, sleep, and physical activity patterns. Each report of a health condition was counted as one event and the total number of personal health events was calculated as well as the total number of family health events reported among immediate family members. Participants self-reported physical activity through open-ended questions of how many minutes of both vigorous and moderate physical activity were completed per week (asked as individual questions with examples provided for each intensity of activity). All vigorous intensity minutes were converted to moderate intensity (1 minute of vigorous intensity exercise = 2 minutes of moderate intensity exercise) to create a single numerical value for each participant.[5] Sleep data was also self-reported as less than 7 hours, 7-8 hours, 8-9 hours, or more than 9 hours.[6] The pre-participation questionnaire also distinguished athletes from non-athletes. Athletes were defined as those who were current collegiate athletes on campus and participating in a regulated strength and conditioning program. All other participants who did not fit these criteria were classified as non-athletes. Older adults were defined as adults 65 years of age and older. Participants were instructed to arrive to their scheduled testing session having refrained from food and exercise for at least four hours prior to testing and refrained from caffeine the day of data collection.[7] A research staff member verbally confirmed this information with the participant prior to RMR testing.

Anthropometric measurements were taken including height, weight, waist and hip circumferences, and body composition. Three trained research staff members conducted all measurements for consistent and accurate techniques. Weight was measured with minimal clothing to the nearest 0.1kg, and height to the nearest 0.1 cm (Seca 700, Seca, Chino, CA). Waist and hip circumferences were measured to the nearest 0.1 cm, and body composition assessed via skinfold calipers. Body composition was estimated using the three site formulas for men (chest, triceps, subscapular) and women (triceps, suprailiac, abdominal).[8] Waist to hip ratio (WHR) was calculated by dividing waist circumference by hip circumference.[8] RMR was then measured via indirect calorimetry (CardioCoach, KORR Medical Technologies, Salt Lake City, UT). Participants sat upright in a chair with a nose clip securing the opening of the nostrils and were instructed to breathe normally while keeping a tight seal around the breathing tube for the duration of the test (approximately 15 minutes).

2.3 Statistical Methods One-way ANOVAs compared MF between BMI categories. Tukey HSD post-hoc analyses were then used to evaluate any differences present. MF for each category is presented as mean ± SD. Differences between groups are presented as mean differences ± SE. Independent sample t-tests compared MF between two groups of populations (athletes vs non-athletes, and general adults vs older adults). Pearson correlations evaluated potential relationships between MF and multiple variables including waist-to-hip ratio, percent body fat, sleep, physical activity, and personal and family health history. Statistical significance was accepted at the level of $p < .05$. Analyses were conducted using IBM SPSS Statistics version 24 (IBM Corporation, Armonk, NY).

3. Results

3.1 Participants Ages of participants ranged from 18-91 years of age (Table 1). Of the 67 subjects, 61% were female (n=41) and 39% were male (n=26). The majority of participants were White/Caucasian (94.0%, n=63) and current college students (68.6%, n=46). The older adults made up 16.4% of participants (n=11). One individual was underweight (1.5%), while 49.3% (n=33) were of normal BMI, 38.8% (n=26) were overweight, 7.5% (n=5) were obese class I, and 3.0% (n=2) were obese, class II.

Table 1. Participant demographics (Mean ± SD) compared to Davis et al. (2)

	Simpson Metabolism Study n=67	Davis et al. (2) n=121
MF	10.9 ± 2.4	9.7 ± 2.4
Age	34.8 ± 24.4	43.6 ± 12.9
BMI	25.0 ± 3.9	36.3 ± 12.9
% Body Fat	19.8 ± 6.9	Not measured
Waist-to-hip ratio	0.79 ± 0.07	Not measured
Personal Health History Events	1.3 ± 1.2	Not measured
Family Health History Events	4.7 ± 6.3	Not measured
Total Health History Events	7.7 ± 5.1	Not measured
Moderate Physical Activity Minutes/Week	529 ± 448	Not measured

Total health history events is defined as the number of personal health history events plus the number of events reported among first-line family members. MF, metabolic factor; BMI, body mass index.

3.2 Metabolic Factor The average MF of all 67 subjects was 10.9 ± 2.4. Our sample was divided into BMI categories of underweight (<18.5), normal (18.5-24.9), overweight (25.0-29.9), obese class I (30.0-34.9) and obese class II (35.0-39.9). Table 2 shows the average MF for each BMI category from the current study as well as Davis et al.[2] MF was similar for each BMI category between the two studies. Figure 1 graphically displays the comparison of MF across BMI categories. Significant differences in MF were found in the current study between the obese class II and normal BMI categories (mean difference 4.85 ± 1.61, p =.02) and between the obese class II and overweight categories (mean difference 4.42 ± 1.63, p =.042). A statistical trend was present between obese class I and normal BMI categories (mean difference 2.63 ± 1.06, p =.074). Significant, inverse correlations were found between MF and age (r = -.433, p = <.0001), BMI (r = -.387, p = .001), and percent body fat (r = -.515, p = <.0001), while physical activity was positively associated with MF (r = .420, p < .0001). Age was also positively associated with percent body fat (r = .33, p = .006) and WHR (r = .535, p = <.0001).

Figure 1. Metabolic Factor across all body mass index (BMI) categories

Image depicts a graphical representation of mean metabolic factor for all body mass index (BMI) categories. Differences in metabolic factor were significantly different between normal BMI and obese class II (mean difference 4.85 ± 1.61, p =.02) and between overweight BMI and obese class II (mean difference 4.42 ± 1.63, p =.042).

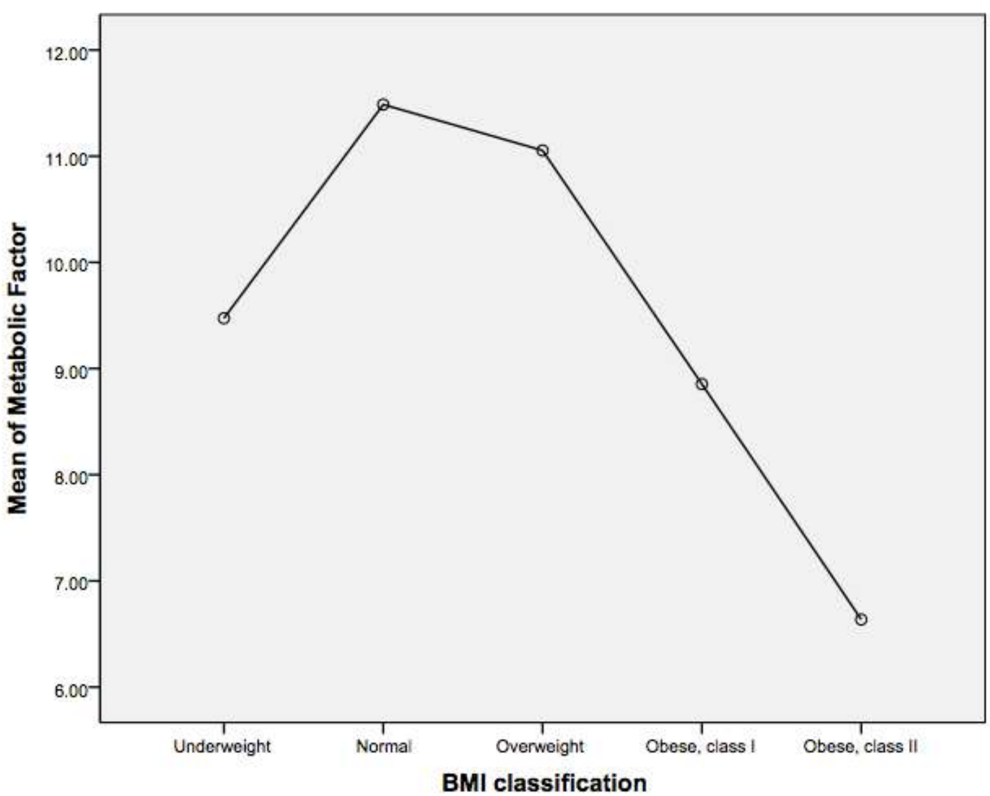

Table 2. Average Metabolic Factor for BMI groups compared to Davis et al. (2)

	Simpson Metabolism Study	Davis et al. (2)
Underweight	9.5 (n=1)	- (n=0)
Normal	11.5 ± 2.1* (n=33)	12.8 ± 1.9 (n=28)
Overweight	11.1 ± 2.3 (n=26)	10.6 ± 1.5 (n=26)
Obese, Class I	8.8 ± 2.7 (n=5)	9.4 ± 1.6 (n=8)
Obese, Class II	6.6 ± 0.31 (n=2)	8.5 ± 0.6 (n=13)
Obese, Class III	- (n=0)	7.9 ± 1.3 (n=46)
Obese (All classes#)	8.2 ± 2.3 (n=7)	8.3 ± 1.5 (n=67)
All	10.9 ± 2.4 (n=67)	9.7 ± 2.4 (n=121)

#All classes of obesity combined within each individual study. No participants had a BMI of obese class III in the current study.

Athletes had a significantly higher MF compared to the MF of non-athletes (Table 3; mean difference 1.74 ± 0.61, p =.006). Older adults had a significantly lower MF than the general adult population of 18-64 years (mean difference 2.68 ± 0.72, p <.0001). Table 4 shows the average age, BMI, WHR, percent body fat, and MF for each age group of adults.

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Table 3. Descriptive and metabolic data of athletes vs non-athletes

	Athletes (n = 19)	Non-athletes (n = 48)	P-value
Age	20.4 ± 1.2	40.5 ± 26.8	< .0001
BMI	24.6 ± 2.9	25.2 ± 4.3	NS
WHR	0.79 ± 0.05	0.80 ± 0.08	NS
% Body Fat	16.3 ± 7.3	21.3 ± 6.4	.008
MF	12.2 ± 1.9	10.5 ± 2.4	.006

Significance was defined as $p < .05$. BMI, body mass index; WHR, waist to hip ratio; MF, metabolic factor; NS, not significant.

Table 4. Descriptive and metabolic data of general adults vs older adults

	Age 18-64 (n = 56)	Age 65+ (n = 11)	P-value
Age	24.9 ± 10.4	84.8 ± 6.1	< .0001
BMI	24.5 ± 3.4	27.5 ± 5.5	NS
WHR	0.78 ± 0.06	0.88 ± 0.08	< .0001
% Body Fat	19.0 ± 6.9	24.1 ± 5.8	.025
MF	11.4 ± 2.2	8.7 ± 1.8	< .001

Significance was defined as $p < .05$. BMI, body mass index; WHR, waist to hip ratio; MF, metabolic factor; NS, not significant.

3.3 Additional Variables Summary data for body composition, WHR, health history, and physical activity for all participants is reported in Table 1. No relationship was present between MF and the variables of average hours of sleep per night or WHR. A significant inverse relationship existed between personal health history and MF (r = -.317, $p = .009$), while no relationship was found between MF and family health history.

4. Discussion and conclusion

4.1 Discussion The primary purpose of this study was to explore the potential use of MF in clinical weight counseling by attempting to replicate and expand the findings by Davis et al.[2] The findings of the current study support the previous results as a significant inverse correlation was present between BMI and MF and the MF among higher BMI categories was significantly lower than the MF of lower BMI categories. This suggests that MF may be a unique characteristic that would predispose an individual to a particular BMI category. An additional study done by Davis et al. demonstrates the stability of MF.[3] As bariatric surgery patients lost weight, their MF remained unchanged. This is likely because weight and RMR decreased in the same proportion.

This study not only replicated previous findings, but expanded existing research on MF by looking at specific populations. When subjects were split into sub-groups according to age, there was a significant difference between MF of general younger adults compared to older adults. Older adults had a lower MF and a higher BMI, while younger adults had a higher MF and a lower BMI. The MFs of athletes and non-athletes were significantly different from each other with the athletes having a higher MF than non-athletes. As expected, the athletes also had a lower BMI and improved body composition. These results show that typical variables known to influence metabolism such as age, physical activity, and body composition, understandably also influence MF.

4.2 Practice Implications Because MF is associated with BMI and is a stable characteristic descriptive of metabolic rate, it has profound implications for use in a clinical setting for weight management. Knowledge of a patient's MF could help clinicians choose an appropriate weight loss intervention. For example, an individual with a low MF may have a more difficult time with natural weight loss because they don't require as many calories to be consumed from the diet in order to maintain energy balance. Because a restrictive diet may not be effective, surgical interventions may be necessary more frequently in this population. Once an individual reaches a certain body weight at which their body seems to maintain despite further caloric restriction or expenditure, it may be necessary to begin counseling the patient on body acceptance. Contrary, an individual with a high MF expends more calories per pound of body weight, so these individuals may be more successful at losing weight via diet and physical activity. Collaboration with and referral to an exercise professional and registered dietitian would be appropriate and encouraged to foster an interdisciplinary healthcare team. It is important to note that several smaller and portable devices such as the one used in the present study, make it very feasible and cost-effective for clinicians to measure RMR in an office without a large cumbersome and expensive metabolic cart.

Currently, BMI is the standard weight to height ratio that is typically used in clinical settings. BMI is flawed because it does not take into account body composition. It is generally understood that an overweight BMI does not necessarily mean the person is unhealthy or at an increased risk of disease. Clinicians could be discouraging patients by telling them they need to fit into a certain BMI category to be considered "healthy". Instead of using a standardized BMI scale, MF could be used to help individuals understand their personal metabolism. It is important to mention that MF should not be used as an excuse as to why someone is overweight or obese, but instead should be used to encourage those who fall into the overweight or obese BMI categories yet are eating well and meeting exercise recommendations to maintain their healthy lifestyle and shift their focus away from the number on the weight scale. In their case, falling into an overweight or obese category may not be inherently unhealthy as long as they maintain healthy behaviors. This has been demonstrated by a wealth of data observing lower morbidity and mortality rates for individuals that are overweight or obese yet maintain appropriate cardiorespiratory fitness levels compared to thinner, yet unfit counterparts.[9] Individuals shouldn't feel like a failure for not being able to lose the weight, but instead should be educated about how their body functions metabolically.

4.3 Conclusion Limitations of the study exist. The majority of the sampled population was Caucasian. It is unknown if and how race or ethnicity impacts MF and is an area for future research. One additional limitation of the sample was that the older adults recruited were highly active, which may not accurately represent the entire older adult population. Despite this, the hypothesized findings with regards to increased age and lower MF were still present. In future studies, additional older adults should be included so the role of age on MF can be more accurately understood. Another limitation is that in the pre-participation questionnaire, participants appeared to over-report their physical activity patterns. Each participant was contacted to verbally clarify their physical activity report to more accurately estimate this variable. While the mean physical activity reported is still considerably high, it is noted that a large portion of the sampled population were current college athletes that participated in structured physical activity for several hours a day. Similarly, the large standard deviation can be explained by the sample including both these collegiate athletes as well as very inactive adults reporting no physical activity. Future research would involve a more detailed and validated physical activity questionnaire, or a structured interview to get a better understanding of physical activity patterns. Regardless of these limitations, it is important to recognize that the findings related to PA and MF were present in the direction one would anticipate finding.

Future research could expand upon the limited data presented in the current study on individuals with an underweight BMI. Interestingly, the one observed data point in the present study with an underweight BMI had a MF similar to the individuals with an obese BMI (Figure 1). Additional research could also explore the impact of weight gain as well as different weight loss programs on MF (i.e. diet only, exercise only, or a combination approach). While the current study supports the validity and clinical uses of MF, longitudinal studies on MF are lacking. Determining how MF changes throughout the lifespan within one individual is relevant and important for expanding the applicability of MF.

RMR is influenced by many variables in the general population. Physical activity is known to have a favorable effect on an individual's metabolism, but it should be understood that age has an undeniable negative association with RMR as the current study witnessed lower MF with advancing age even with regular physical activity participation. MF presents as a promising clinical tool to predict successful weight loss and guide conversation for clinicians on body awareness, weight management, and "health at every size".

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