Resting Metabolic Rate Variability as Influenced by Mouthpiece and Noseclip Practice Procedures

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Mouthpiece and noseclip introduction affect resting physiologic function (i.e., hyperventilation, anxiety), which can influence a resting metabolic rate measurement. It also is obvious that practice is required to minimize this influence when such apparatuses are used. However, the type of practice that best minimizes this influence has not been established. To determine the effect of acute and longer term practice on measurement variability of resting metabolic rate, 27 healthy, premenopausal women were randomly assigned to one of three groups: (1) a practice group, involving three 10-minute practice sessions 1 day to 1 week before resting metabolic rate was measured (n = 9); (2) an acclimation group, in which each subject acclimated to the mouthpiece and noseclip for 5 minutes before the resting metabolic rate measurement (n = 8); and (3) a control group (no practice) (n = 10). Resting metabolic rate was measured three times for each subject via a 5-minute oxygen uptake in the early morning (5:00 to 8:30 am) after a 25-minute supine rest. Resting metabolic rate measurements (kJ/day) and intraindividual variance estimates, adjusted for age and weight, were calculated to determine which practice group had the lowest resting metabolic rate measurement and the lowest variability around each individual's repeated resting metabolic rate measures. Of the three averaged resting metabolic rate measures, significantly lower 24-hour energy expenditures were found with the practice (5647 kJ) and acclimation (5550 kJ) groups when compared with those of the control group (6077 kJ) ($p < 0.001$). Moreover, the standard deviation (variance) of the acclimation group (±178 kJ) tended to be lower than that of the practice (±306 kJ; $p = 0.06$) and control groups (±313 kJ; $p = 0.07$). It is concluded that either previous or acute practice is a necessary part of an initial resting metabolic rate measurement. Furthermore, it is suggested that when influenced by a mouthpiece and noseclip, resting metabolic rate measurement variability may be minimized by practicing the procedure acutely for 5 minutes immediately before the 25-minute supine rest period that precedes the actual resting metabolic rate measure. (J BURN CARE REHABIL 1993;14:573-7)

The use of a mouthpiece and noseclip can alter breathing patterns and thereby result in changes in respiratory frequency and volume.[1-3] Moreover, apprehension or anxiety caused by unfamiliarity with the mouthpiece and noseclip may influence arousal and produce additional error in a resting metabolic rate (RMR) measurement. It is apparent that a period of training is required to reduce the variability associated with a resting metabolic rate measurement.[4,5] However, multiple practice sessions and/or multiple measures are not available or affordable for most individuals in a clinical setting in which only one RMR test is often conducted. It is in this context that a need is created for a practice technique that involves minimal interaction between the client and the testing facility. If only one RMR measure is available, it is very important that a practice technique is chosen that best minimizes the initial influence of unfamiliarity with the measurement device (i.e., mouthpiece and noseclip).

It is obvious that a practice session is necessary before an RMR measurement is collected, but exactly what type of practice results in the most accurate

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Table 1. Subject characteristics

Group	Age (yr)	Height (cm)	Weight (kg)	*n*
Practice	[a]28 ± 5	[a]166 ± 5	[a]61.4 ± 8	9
Acclimation	[b]29 ± 5	[ab]170 ± 6	[b]61.5 ± 4	8
No practice	[ab]35 ± 9	[b]164 ± 6	[ab]56.4 ± 8	10

Values with the same letter suprascript are significantly different at $p \leq 0.01$.

RMR measure has not yet been determined. It can perhaps be reasoned that longer term, repeated use of a mouthpiece and noseclip would be more comforting to the subject and result in a lower and thus more accurate RMR measurement than a single, acute exposure to this apparatus. However, as mentioned earlier, long-term practice is usually not available in the clinical setting. Would one acute practice session be comparable to longer term practice? In attempting to resolve this issue, this study examined the effects of long-term practice and acute practice procedures on RMR measurements when a mouthpiece and noseclip were used. It was hypothesized that both practice groups would have lower RMR measurements than a no practice control group. Furthermore, it was hypothesized that in addition to being a more acurate measure of RMR, the individual variability (standard deviation) about the repeated RMR measures would be lower with the practice techniques.

METHODS

Twenty-seven premenopausal female volunteers (Table 1) were recruited for RMR measurements. Each subject provided written informed consent, and the study was approved by the Cooper Institute for Aerobics Institutional Review Board. All subjects were active individuals with no underlying medical disorders and reported no consistent medication usage. Subjects were randomly assigned to one of three groups upon entrance into the study. Three RMR measurements were taken for each subject in every group. Subjects were scheduled for an RMR measure every 7 days.

The first group (n = 9) was a practice group in which subjects were asked to report to our laboratory for three practice visits before any data were collected for the three RMR measurements. At each of the three practice visits, the practice group was instructed to lie supine on a gurney, and a mouthpiece and noseclip were introduced to the subject for a period of 10 minutes. On the actual testing days, a 25-minute supine rest without the mouthpiece or noseclip was followed by a subsequent 5-minute RMR measure with this apparatus.

The second group was an acclimation group (n = 8) that was familiarized with the mouthpiece and noseclip only on the 3 days of the RMR measurement. Before the 25-minute rest period and subsequent 5-minute RMR measure, each subject lay supine and was introduced to the mouthpiece and noseclip for 5 minutes. After 5 minutes the mouthpiece and noseclip were removed and the subject allowed to rest for 25 minutes before the mouthpiece and noseclip were reintroduced and the 5-minute RMR measure was taken.

The third group (n = 10) was a no practice group that simply reported to the laboratory for three RMR measurements and was instructed to lie supine for 25 minutes before the 5-minute RMR measure was taken.

RMR was measured in the morning hours (5:00 AM to 8:30 AM) after a fast for 12 hours, no exercise for at least 24 hours before the measure, avoidance of sunbathing for 48 hours before the measure, no change in dietary habits during the course of the study, and no consumption of any medication (including aspirin) for at least 24 hours before the RMR measure. Each subject was asked to remain in bed until the necessary time to drive to our laboratory for her appointment. RMR measures were scheduled on days designed to avoid each subject's menstrual period.

RMR was determined by indirect calorimetry in a dark and quiet laboratory maintained at 25° to 26° C. Respiratory data were collected with a SensorMedics MMC Horizons System metabolic cart (Yorba Linda, Calif.). The machine was calibrated before and checked after each test. A drift in the oxygen sensor of .05% would result in a 1.2% error in the oxygen uptake reading, and a drift of

Table 2. Group means and SD across trials for RMR measures

Group	Trial 1	Trial 2	Trial 3
Practice			
VO_2	203 ± 20	203 ± 22	197 ± 23
kJ	5904 ± 582	5904 ± 640	5730 ± 669
Acclimation			
VO_2	198 ± 20	197 ± 16	197 ± 19
kJ	5759 ± 582	5730 ± 465	5730 ± 553
No Practice			
VO_2	198 ± 25	190 ± 17	192 ± 25
kJ	5759 ± 727	5526 ± 494	5584 ± 727

Repeated measures ANOVA revealed no group by trial interaction. Vo_2 values are in ml/min. Kilojoules are determined from a standard respiratory exchange ratio of .82 (1 L of oxygen = 20.198 kJ).
SD, Standard deviation; *VO_2,* oxygen uptake.

.1% would result in a 2.3% error. Of our 81 oxygen uptake readings, 66 were within a .05% drift and the remaining 15 were within .1%. The spirometer was calibrated at 0.9 L and performed within an error of 1% or less. A Hans-Rudolph respiratory valve (no. 2700, Kansas City, Mo.) with a 3 cm diameter rubber mouthpiece was placed in the subject's mouth and held in position via a mechanical arm for the sampling period. A noseclip was used to seal the nose. Gas samples were collected over a 5-minute period.

STATISTICS

A repeated measures analysis of variance (ANOVA) was performed to determine whether there was a group across trials interaction. An analysis of covariance (ANCOVA) also was completed to determine between group differences for each trial. An ANCOVA was used to adjust for age and weight differences between groups (as a result of random selection, age and weight differences were evident at the study onset).

An individual mean and an individual standard deviation were obtained from the three measures of RMR for each subject, and these were then averaged by group. An ANCOVA also was used to detect any significant differences in these mean values and standard deviations (variance).

RESULTS

Repeated measures ANOVA on oxygen uptake and 24-hour kJ energy expenditure indicated no group by trial interaction (Table 2). Therefore all three groups showed similar responses to the measure

Table 3. ANCOVA; Resting oxygen uptake (ml/min) adjusted for age and weight

Group	Trial 1	Trial 2	Trial 3
Practice	[a]195	196	189
Acclimation	[b]190	191	190
No practice	[ab]211	200	205

Values with the same letter suprascript are significantly different at the p level indicated; a, $p = 0.04$, b, $p = 0.01$.

across the three trials. However, an ANCOVA adjusted for age and body weight between groups for each individual trial found a significant difference for oxygen uptake between the control and practice groups ($p = 0.04$) and between the control and acclimation groups ($p = 0.01$) for the first trial only (Table 3). No differences between groups were evident for the latter two trials.

A further ANCOVA indicated that when all three trials were averaged together for each individual, a larger oxygen uptake was seen for the control group as compared with that of the practice and acclimation groups ($p < 0.009$) (Table 4). Statistically significant differences also were found between the acclimation and practice groups as compared with the control group in every mean ventilatory and energy expenditure measure.

The data in Table 4 also suggest lower oxygen uptake variance (standard deviations) associated with the acclimation group when compared with the practice ($p = 0.09$) and no practice groups ($p = 0.13$), but the difference did not attain statistical significance. A significant difference did exist between the standard deviations of the RER measures among the

Table 4. ANCOVA; Intraindividual resting metabolic rate means and SD adjusted for age and weight

Group	VO_2 (ml/min)	VCO_2 (ml/min)	Vent (l/min)	RER	kJ (24 hrs)	.82 kJ (24 hrs)
Practice	[a]193 ± 10[c]	[a]161 ± 9	[a]6.1 ± 0.4	[a].83 ± 0.02[c]	[a]5647 ± 306[c]	[a]5625 ± 303[c]
Acclimation	[b]191 ± 6[cd]	[b]157 ± 8	[b]5.8 ± 0.4	[b].82 ± 0.03	[b]5550 ± 178[cd]	[b]5541 ± 184[cd]
No Practice	[ab]206 ± 10[d]	[ab]187 ± 12	[ab]7.0 ± 0.6	[ab].90 ± 0.05[c]	[ab]6077 ± 313[d]	[ab]5974 ± 300[d]
	a, $p = 0.009$	a, $p = 0.0001$	a, $p = 0.003$	a, $p = 0.002$	a, $p = 0.001$	a, $p = 0.009$
	b, $p = 0.002$	b, $p = 0.0001$	b, $p = 0.0001$	b, $p = 0.0007$	b, $p = 0.0001$	b, $p = 0.002$
	c, $p = 0.09$			c, $p = 0.007$	c, $p = 0.06$	c, $p = 0.09$
	d, $p = 0.13$				d, $p = 0.07$	d, $p = 0.13$

Values with the same letter suprascript are significantly different at the p level indicated. Letters a and b are for the mean values; letters c and d are for the standard deviations.
All values are resting figures.
SD, Standard deviation; *VO_2,* oxygen uptake; *VCO_2,* carbon dioxide output; *Vent,* ventilation; *RER,* respiratory exchange ratio; *kJ,* 24-hour energy expenditure based on individuals RER thermal equivalent for oxygen[7]; .82 kJ, 24-hour energy expenditure based on a standard RER of .82 (1 L of oxygen = 20.198 kJ).

practice and no practice groups ($p = 0.007$). When an individual's RER was used in determining the thermal equivalent for oxygen, differences between the acclimation group and the other two groups are still evident but again, statistical significance was not achieved ($p < 0.07$).

DISCUSSION

From this study and other investigations,[4,5] it appears evident that practice is necessary for an accurate RMR measure on the first visit to a testing facility. The data further indicate that an acute exposure to practice is comparable to longer term practice. The variability (standard deviation) around an individual's average energy expenditure (kJ/24 hours) measure also was lower for the acclimation group; however, this was not statistically significant. Although chance cannot be ruled out for this finding, a low RMR that is similar to a longer term practice group in addition to the minimal variability for the acclimation group may warrant the clinical use of this method.

If any practice technique was to reveal an effect over repeated trials, it would show up as a gradual reduction in RMR with each repeated measure.[4] This trend was not evident for both the practice and acclimation groups, which would indicate that each practice technique was sufficient in minimizing measurement influence (Table 2; unadjusted data). However, for the control group, it is difficult to explain why a group by trial comparisons failed to reveal a trend over time with each RMR measure. Perhaps a type II statistical error reflected by an inadequate sample size is to blame. An RMR measurement is subject to small biologic variability[4] over time, and this may indicate a need for a larger sample size to determine if differences do indeed exist. Nonetheless, differences were obvious for the first RMR measure between the two practice groups and the control group (Table 3; adjusted data). In addition, an intraindividual group average of all three trials adjusted for age and weight revealed significant differences between the two practice groups and the control group for every gas exchange and energy expenditure value (Table 4). This is an indication of the usefulness of practice with the mouthpiece and noseclip.

Although both acute acclimation and longer term practice appear comparable in minimizing measurement influence on an RMR measure and thus provide a low and accurate RMR measure, it is believed that minimizing the individual variability around each measure also is of importance. Perhaps the acute effect of practice immediately before the RMR measure is better able to prepare the subject for the subsequent measurement. Arousal, independent of ventilatory parameters, may be of importance because the carbon dioxide, ventilation, and RER values between the acclimation and practice groups were not different and therefore, hyperventilation could not account for all of the variability in oxygen uptake that was seen between these two groups. It is obvious that the RMR measure can be difficult to control, and it seems logical that any influence on arousal can produce additional error in the RMR measure.[6] On the other hand, use of variance differences can be considered a misleading approach to this study design, because by the second and third trials the acclimation group would then be considered to have undergone longer term practice. So too would the control group.

Further investigation is needed to substantiate when the best time to initiate mouthpiece and noseclip practice is to minimize RMR variability. For example, a 10-minute sample time in which the first 5 minutes of data are not collected or discarded may prove to be more effective than the present acclimation technique. To the contrary, if arousal is to blame for our differences, then the 25-minute rest between practice and RMR measurement for our acclimation group may be necessary to eliminate any initial arousal caused by incipient mouthpiece and noseclip introduction.

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