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Reading and Listening to Music Increase Resting Energy Expenditure During Indirect Calorimetry in Healthy Adults

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ABSTRACT

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The Academy of Nutrition and Dietetics has developed an evidence analysis library (EAL) for Nutrition and Dietetics professionals. The EAL is updated by members through workgroups consisting of experts in their fields, most often in response to unanswered questions. One such question is: what kinds of activities can be done during the rest period of an indirect calorimetry test in a healthy population? The objective of our study was to determine if listening to self-selected relaxing music or reading on an electronic device or a magazine effects resting energy expenditure (REE) as measured by an indirect calorimetry test in a healthy population. Answering this question would help indirect calorimetry test administrators know if these simple activities can be done during an indirect calorimetry test without significantly affecting REE but helping subjects remain awake. It would also help standardize the current protocol for indirect calorimetry administration. A randomized trial was conducted during an indirect calorimetry test, under three different conditions (resting, reading, listening to music). Six-five subjects (36 females and 29 males) were used in final data analysis. Inclusion criteria included healthy subjects between the ages of 18-50 years with a stable weight. Exclusion criteria included pregnant or lactating women or individuals who were taking medications known to affect metabolism. Reading, either a magazine or electronic device, resulted in a significant increase of 102.7 kcal/day when compared to resting ($p<0.0001$). There was no difference in REE when subjects read a magazine or on an electronic device. Listening to self-selected relaxing music increased REE by 27.6 kcal/day compared to rest ($p=0.0072$). Based on our results, we recommend subjects refrain from reading a magazine or electronic device during a test. Whether or not the smaller difference found while listening to music is practically significant would be a decision for the indirect calorimetry test administrators. Further research could be done to determine the effects other activities have on REE during an indirect calorimetry test. Such activities could include; watching television, texting, or playing passive game.

Key Words: indirect calorimetry, resting energy expenditure, reading, relaxing music, healthy adults

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INTRODUCTION

Indirect calorimetry is the most common technique for measuring resting energy expenditure (REE) in both clinical and research settings [1]. Indirect calorimetry analyzes pulmonary gases, namely O_2 consumption and CO_2 expiration, to obtain a more accurate REE than can be predicated through equations [1-4]. The current protocol to conduct an indirect calorimetry test instructs that the test is performed early in the morning (between 5am-8am), in a thermoneutral room, with low lighting, minimal sounds and distractions, following an overnight fast and that the subject remains awake and still [1-4]. Given the circumstances of this protocol, subjects often fall asleep. In a 2004 study performed by Kumahara *et al*. [5] it was discovered that REE can decrease up to 5% when sleeping, therefore, to get an accurate REE measurement, it is important that subjects remain awake during the test.

To assist nutrition professionals in their efforts to use evidenced based practice the Academy of Nutrition and Dietetics has developed an evidence analysis library (EAL). The EAL is most often updated in response to questions that are unanswered or unsupported by quality research. One such question is: what kinds of activities can be done during the rest period of an indirect calorimetry test in a healthy population?

The results of a variety of studies have proven that REE can be affected by several activities and factors, such as, playing active video games, music, our physical environment, and laughter [5-20]. However, the majority of these studies were designed to explore the impact of different activities on REE and its relationship to obesity. They were not intended to find acceptable activities that could be done during an indirect calorimetry test to further define current protocol. To the best of our knowledge, there have been no studies done testing the effect of reading on REE. Further research is warranted to determine if there are activities that can be done to help subjects remain awake without significantly affecting their REE during an indirect calorimetry test.

This purpose of this study was to determine if simple activities such as reading or listening to music significantly affects REE during an indirect calorimetry test. Answering this question would help those administrating indirect calorimetry tests know if these activities could be done during an indirect calorimetry test without significantly affecting REE but helping subjects remain awake.

METHODS

Study design

A randomized trial was conducted with indirect calorimetry under three different conditions (resting, reading, listening to music). Subjects were exposed to each condition, with the sequence of exposure assigned randomly. Randomization was achieved with three different colored marbles chosen from a concealed container. Marbles were similar in size and texture. Music and reading material was self-selected.

Description of Study Subjects

A convenience sample of 68 male and female subjects were recruited from the faculty and staff at Brigham Young University (BYU) and in the surrounding community. Recruitment efforts involved flyers sent to all faculty and staff at BYU and displayed throughout campus, announcements made in specific classes, and by word of mouth. Inclusion criteria included healthy subjects between the ages of 18-50 years at a stable weight, defined as no weight loss or gain exceeding 2.3 kg (5 lbs) in the past 6 months. Exclusion criteria included pregnant or lactating women and subjects taking medications known to affect metabolism. BYU Institutional

Review Board (IRB) approved the study protocol and all participants provided written informed consent

Procedures

Following recruitment, subjects were screened through email to match inclusion criteria. If inclusion criteria were met, a short initial visit was scheduled at the subject's convenience. During this visit height and weight were obtained, study procedures were explained, the informed consent was read and signed, and music and reading preferences were indicated. A time to have indirect calorimetry measurements taken was also scheduled during this initial visit. The measurements occurred within one week of the initial visit. Randomization of condition exposure was done prior to the initial visit.

Music was chosen from a variety of Pandora® stations played on a provided iPad 2 (Apple Inc, Cupertino, CA). Subjects were given the choice to read on the provided iPad 2 or they could choose from a wide variety of print magazines. They also had the option of bringing in their own music, magazine, and/or electronic device (iPad, Kindle, etc.). If subjects brought in their own devices they were instructed to have them fully charged. With the exception of turning pages, subjects were instructed to remain as still as possible during the reading portion of the test.

Anthropometrics

Height was measured using a professional grade stadiometer, Model PE-WM-60-76-BRG2 (Perspective Enterprises, Portage, MI). Subjects were measured while standing, without shoes, and weight evenly distributed. Height was measured to the nearest .5 in. Weight was assessed with a Tanita 310 electronic scale (Arlington Heights, Illinois). Subjects were weighed only once, prior to the indirect calorimetry measurement, with light clothing and without shoes. Weight was recorded to the nearest 0.5 lb.

Indirect Calorimetry Measurements

The information obtained during the initial visit was used to have the music and reading preferences ready for each subject prior to having measurements taken. Tests followed current protocols including: starting the test between 5:00 am and 8:30 am, following an overnight fast, and no shower the morning of the test. They were allowed to shower the night before. Subjects were asked to park as close to the building and to abstain from any exercise or caffeine at least 12 hours prior to the tests. Subjects rested for 30 minutes in a supine position prior to data collection where a light blanket was provided, if desired [21]. All measurements were taken in a quiet, thermoneutral room with dimed lights to avoid any environmental influences on REE.

A VMAX 29N indirect calorimeter (SensorMedics, Yorba Linda, CA) was used to take all measurements. Calibrations on the mass flow sensor and gas analyzers were performed prior to each study. Gases used for calibrations are Cal 1: 20% O_2/ 75% CO_2 and Cal 2: 26% O_2/0% CO2. A clear canopy was placed over the subject's head to collect gas samples. Each condition (resting, reading, listening to music) was measured for 25 minutes, for a total of 75 minutes; data collected in the first five minutes was discarded in each condition [21].

Sol Tracks V8 by Sol Republic (Wilsonville, Oregon) headphones were provided for all subjects. Headphones were worn for the duration of all conditions to avoid unnecessary movement and to minimize noise. To control for volume, subjects were given a decibel scale with acceptable ranges highlighted. The max decibel was defined as normal conversation. Transitions from one condition to the next were done through written signs, communicating with the subject to start or pause music and/or to stop or start reading.

Data Analysis

A power analysis based on a practical change in REE of 75 kcals determined a sample size of 50, standard deviation of 150 kcals and $\alpha = .2$ $\beta = .05$. The difference between treatments were determined with mixed model repeated measures of analysis of variance (ANOVA) using SAS (Version 9.3, SAS Institute Inc). Results are reported as least squared means ± standard error (LSM ± SE). Demographic information was analyzed using Microsoft Excel 2010 (Redmond, Washington). Results are reported means, standard deviations, and ranges.

RESULTS

There were a total of 65 (36 females and 29 males) included in the final data analysis. Sixty-eight subjects were recruited matching the inclusion criteria and completed the initial visit; however, three subjects did not come in to have measurements taken due to scheduling conflicts. The demographic characteristics of subjects are described in **Table 1**.

Reading either a magazine or electronic device resulted in a significant increase of 102.7 kcal/day or 6.5% (**Table 2**) when compared to resting ($p<0.0001$). There was no difference in REE between reading a magazine or electronic device (data not shown). Listening to self-selected relaxing music increased REE by 27.6 kcal/day or 1.8% compared to rest ($p=0.0072$).

DISCUSSION

The primary findings of this study suggest that both listening to self-selected relaxing music and reading, either and magazine or on an electronic device, have a significant impact on REE during an indirect calorimetry test. As discussed in a 2012 review by Yamasaki *et al.* [20], data does exists examining the different musical genres on aspects of stress response but the impact of different types of music on specific metabolic responses is a question that has not been extensively pursued. They also noted that several studies have observed the relaxing effect of classical music, whereas genres such as hip hop, techno music and heavy metal are commonly associated with physiologic arousal [20]. Research has also suggested that personal music preferences increase the ability of the music to diminish an individual's stress levels [20].

Consistent with personal preferences playing a role in diminished stress levels, Labbe *et al.* [13] found that healthy volunteers that listened to self-selected or classical music after exposures to a stressor showed significant decreases in self-rated anxiety, whereas those exposed to heavy metal or silence did not [13]. The relaxing effect of classical music was used in a study by Lubetzky *et al.* [15] in preterm healthy infants. They intended to use music by Mozart to lower REE in the infants, hoping it would cause more rapid weight gain and shorten their hospital stay. They found that REE decreased 13% while the infants were exposed to Mozart for 30 minutes compared to no music exposure [13].

Based on the results of these studies and the known physiological effects of relaxing music, it might have been expected that we would have seen a decrease in REE while subjects listened to self-selected relaxing music. However, the definition of the term "relaxing" can vary greatly from person to person. This variability could have played a role in the increase we saw in REE during the music portion of the indirect calorimetry test. On the other hand, the auditory stimulus of music might have raised REE.

Carlsson *et al.* [8] performed a study examining at the effects of calming music (Bach) vs stressful music (Satie). This study was designed to determine if listening to stressful music could increase REE as a possible treatment for obesity. Results showed there was not a significant difference (p=0.57) in REE when subjects listened to calm music (1364 kcal/day) vs. silence (1366 kcal/day). There was also not a significant difference (p=0.43) between silence (1366 kcal/day) and stressful music (1371 kcal/day) [8]. Although this study was similar to ours in protocol, subjects were only exposed to the music selections for 10 minutes each as opposed to 25 minutes in our study. This short exposure might not have been long enough to see the full effects of the music on REE.

Cooper *et al.* [11] tested several different activities on REE in adolescent girls. One activity was listening to a story being read out loud. They found no difference in REE when adolescent girls listened to a story (1320 kcal/day) compared to rest (1346 kcal/day) (p=.066) [11]. The significant increase we found while reading (102.7 kcal/day) in our study could be a result of physically holding an object, whether it be a magazine or electronic device, as opposed to just listening to a story being read.

A potential limitation of the current study is a lack of standardization in the music and reading material provided for the tests. Subjects could choose any type of music they deemed relaxing. Any reading material was also acceptable, as long as it was a magazine or on an electronic device. However, this self-selection could be a possible strength, as self-selection would be more applicable to practice settings. Further research comparing the effects of the same quiet music could be of interest.

CONCLUSIONS

In conclusion, we found that reading and listening to relaxing music under a controlled environment have a significant increase on REE during an indirect calorimetry test. Based on our results, we recommend subjects refrain from reading a magazine or electronic device during a test. Whether or not the smaller difference found while listening to music is practically significant would be a decision for the indirect calorimetry test administrators. Further research could be done to determine the effects other activities have on REE during an indirect calorimetry test. Such activities could include: watching television, texting, or playing passive games.

Table 1: Subject Characteristics

	Mean ± SD	Range
Female (n %)	36 (55.4%)	
Age (y)	27 ± 9	18 - 50
Body Weight (kg)	71 ± 15	46 - 120
Height (cm)	172 ± 9	150 - 193
Body Mass Index (kg/m^2)	24 ± 4	18 - 37

Table 2: Least-square means of REE, RQ, VO_2, VCO_2 for three conditions

	Resting (n=65)	Music (n=65)	Reading (n=65)
	←	*least-square means ± standard error*	→
REE (kcal/day)	1576.1 ± 39.45^a	1603.7 ± 39.45^b	1678.8 ± 39.45^c
RQ (VCO_2/VO_2)	0.80 ± 0.005	0.82 ± 0.005	0.82 ± 0.005
VO_2 (L/min)	0.227 ± 0.006^a	0.231 ± 0.006^{ab}	0.240 ± 0.006^c
VCO_2 (L/min)	0.182 ± 0.005^a	0.189 ± 0.005^{ab}	0.200 ± 0.005^c

^{abc} Means not sharing the same superscript across rows are significantly different ($p<.0001$)
REE-Resting Energy Expediture
RQ-Respirtory Quotient
VO_2-Oxygen Consumption
VCO_2- Carbon Dioxide Production

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APPENDIX A

STATEMENT OF THE PROBLEM

The Academy of Nutrition and Dietetics has developed an evidence analysis library (EAL) for Nutrition and Dietetics professionals. It contains the latest and most up-to-date research to ensure that clinicians have evidence based practice and provide the most accurate information to patients and clients. The EAL is updated by members of the Academy of Nutrition and Dietetics through workgroups consisting of experts in their fields, most often in response to unanswered questions. One such question is: what kinds of activities can be done during the rest period of an indirect calorimetry test in a healthy population?

Indirect calorimetry is the most common technique for measuring resting energy expenditure (REE) in both clinical and research settings [1]. Indirect calorimetry analyzes pulmonary gases, namely O_2 consumption and CO_2 expiration, to obtain a more accurate REE then can be predicted through equations [1-4]. The current protocol to conduct an indirect calorimetry test requires that the test is performed early in the morning (between 5am-8am), in a thermoneutral room, with low lighting, minimal sounds and distractions, following an overnight fast, and that the subject remain awake and still [1-4]. Given the circumstances of this protocol, subjects often fall asleep resulting in a sleeping metabolic rate (SMR). In a 2004 study performed by Kumahara *et al*. [5], it was discovered that REE can decrease up to 5% when sleeping; therefore, to get an accurate REE measurement, it is important that the subject remains awake during the test.

The results of a variety of studies have proven that REE can be affected by several activities and factors, such as, playing active video games, music, our physical environment, and laughter [5-16]. However, these studies were not intended to find acceptable activities that could be done during an indirect calorimetry test. The majority were designed to explore the impact of different activities on REE and its relationship to obesity, not to define a current protocol. Also, to the best of our knowledge, there have been no studies done testing the effect of reading on REE. Further research is warranted to determine if there are activities that can be done to help subjects remain awake without significantly increasing their REE during an indirect calorimetry test.

PURPOSE

The purpose of this study is to:

1) Determine if listening to self-selected relaxing music or reading (on an electronic device or a magazine) affects resting energy expenditure as measured by an indirect calorimetry test a healthy population in an effort to define acceptable protocols for measuring REE in research and clinical settings.

HYPOTHESIS

Null hypothesis: There is no difference in resting metabolic rate while reading or listening to music.

Alternative hypothesis: Both interventions will result in a significant increase in REE in a non-critically ill population.

APPENDIX B

LITERATURE REVIEW

Components of Energy Expenditure

Energy expenditure (EE) is defined as the ability of individuals to do internal and external work [2]. Current literature contains conflicting definitions of the different components of EE and the most optimal conditions to obtain an accurate measurement of the components. The following paragraphs describe the different components of EE and the most collective evidence for accurate measurement.

Basal metabolic rate (BMR) describes the rate of energy expenditure in a subject resting comfortably, supine, awake, motionless and in a post-absorptive state [22]. Ideal measurements are taken at least 12 hours after the last meal to reach the post-absorptive state defined as a situation where the digestive process is completely terminated [1-3, 22, 23]. This ensures that there would be no influence of diet-induced thermogenesis (DIT) or thermic effect of food (TEF) [2, 3, 23]. TEF causes an increase in BMR due to the energy required for digestion, absorption, and disposal of ingested nutrients [24].

BMR represents the energy needed to sustain the metabolic activities of cells and tissues, plus the energy to maintain blood circulation, respiration, gastrointestinal, and renal function [22]. It also includes the cost of arousal, as sleeping can decrease BMR by 5 to 10 percent [5, 22]. BMR is most often extrapolated to kcal/day to make it more meaningful and is referred to as basal energy expenditure (BEE). BEE for healthy adults is primarily a function of body size, or more specifically, fat-free mass [1, 25]. It can also be affected by gender, age, and ambient temperature [1].

Due to the precise methods of measurement of BMR, resting metabolic rate (RMR) is more commonly measured. RMR is also extrapolated to kcal/day and called resting energy expenditure (REE). REE tends to be approximately 10 to 20% higher than BEE due to increases in TEF or by the delayed effect of recently completed physical activity [1-3, 23]. REE is usually measured in the morning, following an overnight fast, in a subject who has laid quietly for at least 30 minutes [23]. The overnight fast is an effort to eliminate the TEF. This thermic effect seems to be influenced by the composition of food consumed [24]. In general, the typical thermic effect of protein is 20 - 35% of energy consumed and for carbohydrate 5- 15% [24]. Kinabo *et al.* [26] found that meals of high energy content of the meal (1200 kcal) had TEF values significantly greater ($p < 0.001$) than those of low energy content (600 kcal). Bielinski *et al.* [27] found the TEF lasted up to 18 hours after subjects were fed 3880 kcal/24hrs. Thus, even with an overnight fast, the TEF could vary greatly depending on the size and content of the subject's last meal and might not be completely eliminated. Therefore, because REE includes TEF, it is more frequently used to predict daily energy requirements for individuals and generally accounts for 60-75% of total energy expenditure (TEE) [2].

Methods of Measuring Energy Expenditure

The process of measuring energy expenditure is known as calorimetry and may be direct or indirect [2, 28]. Direct calorimetry was the original method used to measure energy expenditure in humans [1]. This method measures the heat released by an organism based on the correlation between heat loss and cellular metabolism [1]. A specially designed chamber or restrictive water-cooled bodysuit is used measure this heat loss. Although accurate, this method is often impractical, expensive, and rarely used outside of animal research settings [1, 29].

Indirect Calorimetry

The term "indirect" refers to the fact that energy production is measured via pulmonary gas exchanges, namely O_2 consumption and CO_2 expiration, rather than directly measuring heat transfer [4]. It is the most used technique for measuring energy expenditure in both clinical and human research settings [1]. The measurement of oxygen consumption represents, under ideal conditions, the sum of all the oxidative processes occurring within the body [1]. The measurements of VO_2 and VCO_2 are converted to energy expenditure (kcal/day) by application of the Weir equation [28].

Complete Weir Equation

$$REE = [3.9(VO_2) + 1.1(VCO_2)]\ 1.44 - 2.17\ (UN)$$

Abbreviated Weir Equation

$$REE = [3.9(VO_2) + 1.1(VCO_2)]\ 1.44$$

In this equation VO_2 and VCO_2 are expressed in liters per day and urea nitrogen (UN) in grams per day [2]. The complete Weir equation accounts for the incomplete oxidation of protein [2]. The error for ignoring incomplete the protein correction to energy expenditure was only 1% for every 12.3% protein contribution to total energy expenditure, hence, the abbreviated Weir equation is more typically used [1].

There are two basic types of indirect calorimetry based on VO_2 measurement [28]: Respiration chamber calorimeters, where the subject resides and breathes freely inside a chamber, and portable devices in which expired air is collected via face mask, mouth piece and noseclip, canopy, or from a mechanical ventilator and is funneled into the instrument for analysis [1]. There are hand held devices available as well [1].

When using a face mask or mouth piece with nose clip it is important to ensure a complete seal [2]. Some of the disadvantages to these ways of collecting VO_2 include: inadequate seal, collection of saliva, dry throat, jaw fatigue, and inability to rest. In a canopy system, the patient's head is enclosed in a clear rigid hood [2]. A pump pulls room air through the canopy at a continuous rate, and the gases are shunted to a mixing chamber [2]. The canopy offers an advantage of not altering the patient's breathing patterns, but some people may feel claustrophobic when placed under a canopy [2].

Indirect calorimeters can be further classified into open-circuit and closed-circuit calorimeters [28]. In an open-circuit system VO_2 is determined by measuring the difference between inspired and expired gas concentrations and minute ventilation [28]. The patient's inspired air source is room air or comes from a mechanical ventilator [2]. With a closed-system VO_2 is determined by measuring the volumetric change from a reservoir of oxygen over time [28]. The inspired air source is an air or an oxygen tank in the calorimeter.

Basic protocol before beginning a test should include [2]:

- Subjects have rested in the supine position (in bed or a recliner) for more than 30 minutes before the measurement to avoid the effects of previous voluntary activity on REE
- Measurements are made in a quiet, thermoneutral environment
- Subjects have no skeletal muscle activity (movement of the extremities) during the measurement.
- No leaks are present in the sampling system
- Subject remain awake and still during the entirety of the test

Respiratory Quotient

Carbohydrates, protein, fat, and alcohol are the four types of macronutrients that provide energy in the body [2]. In cellular metabolism of these macronutrients, carbon dioxide is produced, oxygen is consumed, and heat is produced in proportion to the amount of the substrate being oxidized [2]. All current methods of determining energy expenditure and substrate utilization rely on this relationship.

The relationship between cell metabolism, gas exchange, and heat release is constant and therefore each substrate will produce a unique and particular ratio of carbon dioxide production (VCO_2) to oxygen consumption (VO_2). This ratio is known as the respiratory quotient (RQ) [1, 29]. The RQ can serve as an indicator of quality control because in humans it resides in a fairly narrow range (.67-1.3) and is also used to determine substrate utilization [25, 28, 29]. Due to this narrow range, RQ values outside of this range may be interpreted presumably generated by some error in calibration, leak in the system or articfactual influence [25]. In this way, the RQ can be a useful factor to help verify the validity of the indirect calorimetry test [25].

<u>Interpreting the Respiratory Quotient</u> [2]

	RQ (VCO_2/VO_2)
1 ethanol + 6 O_2 → 4 CO_2 + H_20	0.67
1 palmatate + 230 O_2 → 160 CO_2 + 16 H_20	0.71
1 amino acid + 5.1 O_2 → 4.1 CO_2 + 2.8 H_20 + .7 urea	0.82
1 glucose + 6 O_2 → 6 CO_2 + 6H_20	1.0

Thermal Environment

The environment of an indirect calorimetry measurement can have an effect on the results. Humans respond to cold by increasing metabolism, decreasing peripheral body temperature or hypothermia [10]. Celi *et al.* [9] examined the differences in REE under two different temperatures (66°F and 75°F). Their data demonstrated that a 5° reduction in temperature resulted in a consistent increase of about 6% in REE. They concluded that minimal modulation in the environmental temperature results in a significant increase in REE [9] . In a 2007 study, Wijers *et al.* [19] found similar results when 13 lean male subjects were exposed to different environmental temperatures (66°F and 71°F). Wijers' results showed a 5% increase in REE when the subjects were exposed to decreased temperatures [19] .

Effect of Music on Human Physiology

Variations in auditory stimulus intensity, tone, and tempo have been shown to evoke dynamic psychological and physiological responses [6, 18]. In clinical and non-clinical contexts, music has been shown to have a positive influence in wide-ranging fields such as stress reduction, relaxation, pain management, neural cognition, cardiac function, and more [20]. In a 2012 review by Yamasaki *et al.* [20], it was discovered that the impact of different types of music on specific metabolic responses is a question that has not been extensively pursued, even though there is existing data examining the different musical genres on aspects of stress response [20]. This same review noted that several studies have observed the relaxing effect of classical music, whereas genres such as hip hop, techno music and heavy metal are commonly associated with physiologic arousal [20]. Research has suggested that a listener's personal music preferences increase the ability of a specific type of music to diminish an individual's stress levels [20]. There is also evidence that there gender-specific responses to music [20]. Labbe *et al.* [13] found that healthy volunteers that listened to self-selected or classical music after exposures to a stressor showed significant decreases in self-rated anxiety, whereas those exposed to heavy metal or silence did not.

Lubetzky *et al.* [15] evaluated the effects of Mozart music on the REE of 20 preterm infants. Resting energy expenditure was measured while the infants were exposed to music by Mozart for 30 minutes, this was then compared to REE taken without music exposure [15]. All measurements were taken in nearly identical thermal environments. Results showed that when exposed to music by Mozart there was a 10% to 13% reduction in the infants REE as long as the music was heard [15]. However, Carlsson *et al.* [8] found no effect of music on REE in obese adults. Possible explanation for the different results in these two studies could be Carlsson *et al.* used a variety of classical musicians, there was no crossover and they did not control for diet [8].

Activities

Given inconsistent correlations observed in studies of obesity and television viewing, Cooper *et al.* [11], compared the metabolic effects of resting conditions with two different types of television (passive versus active/stimulating) programs and a non-television activity (listening to a story) in obese and non-obese girls. Resting energy expenditure did not appear to be significantly influenced by the type of inactive condition that they girls were in [19]. Pfeiffer *et al.* [17], also studied the variability in EE of selected activities among adolescent girls. Activities included television viewing, playing computer games, walking, step aerobics, stair climbing and running. Their results were consistent with Cooper *et al.* showing no difference between resting and viewing television, however there was significant differences between resting and the other activities [11].

Several studies have compared the change in EE while playing active video games (Wii, Xbox Kinetic) and inactive video games (GameCube, Nintendo DS, PlayStation 2). One such study done by Leatherdale *et al.* [30], found that EE was significantly higher when playing an active video game (97.4 kcal/30 min) compared to inactive video games (64.7 kcal/30min) in adults. Mitre *et al.* [16], examined the effects of video games and television on obese and lean children. Results showed that sedentary or inactive video games and television watching have a small effect on children's EE [16]. Similar to Leatherdale *et al.*'s finding, active video games increased the children's EE significantly. Comparable results were found in a Lanningham-Foster *et al.* [14] study also comparing sedentary screen time with active screen time in children. In this study EE while playing Dance Dance Revolution increased 382 +/- 181 kJ/hour ($p<.00001$).

Laughter

Laughter is a unique human behavior naturally occurring in a variety of social situations [7]. Facial, respiratory, and laryngeal muscles are all recruited for laughter production leading to changes in lung volume and dynamic compression of the airways [7]. These changes lead to increase oxygen consumption and increase heart rate and could also increase EE [7]. Buchowski *et al.* [7] found that there was up to a 20% increase in EE during episodes of laughter than during rest in young adults (1900 kcal +/- 216 vs 1756 kcal +/- 243).

Summary

The results of a variety of studies have shown that REE can be affected by several factors including; sleeping, playing active games, listening to music, the physical environment and laughter in adults, adolescents and infants [5, 7, 9, 12-15, 17-20, 30]. To the best of our knowledge there have been no studies done testing the effect of reading on REE. Also, there are no studies conducted to specifically look at the effect of REE during on indirect calorimetry test. They were mostly done in an effort to test the effect of different activities on REE in response the rise in obesity rates. Therefore, it is evident that more research could be done to further explore the effects of different activities on REE during an indirect calorimetry test to help define current protocol on the test administration.

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APPENDIX C

METHODS

Description of Study Subjects

A convenience sample of 68 male and female subjects were recruited from the faculty and staff at Brigham Young University (BYU) and in the surrounding community. Recruitment efforts involved flyers sent to all faculty and staff at BYU and displayed throughout campus, announcements made in specific classes, and by word of mouth. Inclusion criteria included healthy subjects between the ages of 18-50 years at a stable weight, defined as no weight loss or gain exceeding 2.3 kg (5 lbs) in the past 6 months. Exclusion criteria included pregnant or lactating women and subjects taking medications known to affect metabolism. BYU Institutional Review Board (IRB) approved the study protocol and all participants provided written informed consent

PROCEDURES

Study Design

A randomized trial was conducted to test the effects of listening to self-selected relaxing music or reading (on an electronic device or a magazine) on resting energy expenditure. Following recruitment, subjects came in for an initial visit. During this visit, height and weight were obtained, study procedures were explained and subjects were able to read and sign the informed consent form. Subjects also indicated their music and reading preferences at this initial visit. Indirect calorimetry measurements occurred within one week of initial visit. The sequence of exposure (resting, music, or reading) was assigned randomly. Randomization was achieved with three different colored marbles chosen from a concealed container. Marbles were similar in size and texture.

Interventions

Subjects listened to self-selected relaxing music. Subjects were allowed to choose from a variety of Pandora® stations played on a provided electronic device or were allowed to use their own listening device. Sol Tracks V8 by Sol Republic (Wilsonville, Oregon) head phones were provided for all subjects. To control for volume, subjects were given a decibel scale with acceptable ranges highlighted. The max decibel being defined as normal conversation.

Subjects were given the choice to read on an electronic device (iPad, Kindle, etc) or a magazine. They could use an iPad 2 (Apple Inc, Cupertino, CA) provided or bring in their own electronic device. A wide variety of magazines were provided for them to choose from or they were able to bring in their own. If subjects were bringing in their own devices they were instructed to have the device fully charged. They were also instructed to remain as still as possible during the reading portion of the test, with the exception of turning pages.

Height

Height was measured prior to the indirect calorimetry measurement using a professional grade stadiometer, Model PE-WM-60-76-BRG2 (Perspective Enterprises, Portage, MI). Subjects were measured while standing without shoes, weight evenly distributed. Height will be measured to the nearest .5 in.

Weight

A Tanita 310 electronic scale (Arlington Heights, Illinois) was used to assess weight. Subjects were weighed once, prior to the first indirect calorimetry measurement with minimal clothing and without shoes. Weight was recorded to the nearest 0.5 lb.

Resting Energy Expenditure

Indirect calorimetry tests followed current protocols including: staring the test between 5:00 am and 8:30 am, following an overnight fast and no shower the morning of the test. Subjects parked close to the building and were asked to abstain from any exercise or caffeine at least 12 hours prior to the tests. Subjects rested for 30 minutes in a reclined position prior to data collection. A light blanket was provided if desired. During rest time the majority of the subjects slept, read a magazine or sat quietly. All measurements were taken in a quiet, thermoneutral room with dimed lights to avoid any environmental influences on REE.

A VMAX 29N indirect calorimeter (SensorMedics, Yorba Linda, CA) was used to take measurements. Calibrations on the mass flow sensor and gas analyzers were performed prior to each study. Gases used for calibrations are Cal 1: 20% O_2/ 75% CO_2 and Cal 2: 26% O_2/0% CO2. A clear canopy was placed over the subject's head to collect gas samples for 25 minutes for each intervention (resting, music, reading) for a total of 75 minutes; data collected in the first five minutes was be discarded in each intervention. Subjects wore the provided headphones for the duration of all tests to avoid unnecessary movement and to minimize noise. Transitions from one intervention to the next were done through signs, communicating with the subject to start or pause music and to stop or start reading. Data were averaged whether or not the subjects reach steady state.

Statistical Analysis

A power analysis based on a practical change in REE of 75 kcals determined a sample size of 50, standard deviation of 150 kcals and $\alpha = .2$ $\beta = .05$. The difference between treatments was determined with mixed model repeated measures of analysis of variance (ANOVA) using Statistical Analysis Software (Version 9.3, SAS Institute Inc). Results are reported as least squared means ± standard error (LSM ± SE). Demographic information was analyzed using

Microsoft Excel 2010 (Redmond, Washington). Results are reported means, standard deviations, and ranges.

APPENDIX D

COMPLETE RESULTS

Restatement of the Problem

The Evidence Analysis Library (EAL) has been developed by the Academy of Nutrition and Dietetics to ensure that the most up-to-date research can be provided by clinicians to client and patients. The EAL is updated by members of the Academy of Nutrition and Dietetics that are experts in their fields. These updates are often in response to an unanswered question. One such unanswered question includes; what activities, such as listening to music, reading, or playing games on an electronic device, can be done during an indirect calorimetry test in a healthy population without affecting REE?

Purpose of Study

The purpose of this study was to determine if listening to self-selected relaxing music or reading on an electronic device or magazine affects REE, as measured by an indirect calorimetry test in a healthy population. The findings of which would be in an effort to define acceptable protocols for measuring REE in research and clinical settings.

A power analysis based on a practical change in REE of 75 kcals determined a sample of 50, standard deviation of 150 kcals and $\alpha = .2$ $\beta = .05$. The difference between treatments were determined with mixed model repeated measures of analysis of variance (ANOVA) using SAS (Version 9.3, SAS Institute Inc). Results are reported as least squared means ± standard error (LSM ± SE). Demographic information was analyzed using Microsoft Excel 2010 (Redmond, Washington). Results are reported means, standard deviations, and ranges.

Results

Sixty-eight subjects were recruited and completed the initial visit. Three subjects did not come in for their second visit due to scheduling conflicts and therefore did not have measurements taken. There were a total of 65 (36 females and 29 males) included in the final data analysis. The demographic characteristics of subjects are described in **Table 1**.

Reading, either a magazine or electronic device, resulted in a significant increase of 102.7 kcal/day (**Table 2**) when compared to resting ($p<0.0001$). Listening to self-selected relaxing music increased REE by 27.6 kcal/day ($p=0.0072$). There was no difference between REE when subjects read a magazine or read on an electronic device (data not shown).

The fraction of inspired air (FIO_2), fraction of oxygen in expired air (FEO_2), and fraction of carbon dioxide of expired air ($FECO_2$) were not significantly different between treatments. This indicates that our equipment was working properly and that our measurements are accurate. Individual treatment means, standard deviations, and ranges are represented in **Tables 3, 4 and 5**.

Table 1: Subject Characteristics

	Mean ± SD	Range
Female (n %)	36 (55.4%)	
Age (y)	27 ± 9	18 - 50
Body Weight (kg)	71 ± 15	46 - 120
Height (cm)	172 ± 9	150 - 193
Body Mass Index (kg/m^2)	24 ± 4	18 - 37

Table 2: Least-square means of REE, RQ, VO_2, VCO_2 for three conditions

	Resting (n=65)	Music (n=65)	Reading (n=65)
	←	*least-square means ± standard error*	→
REE (kcal/day)	1576.1 ± 39.45^{a}	1603.7 ± 39.45^{b}	1678.8 ± 39.45^{c}
RQ (VCO_2/VO_2)	0.80 ± 0.005	0.82 ± 0.005	0.82 ± 0.005
VO_2 (L/min)	0.227 ± 0.006^{a}	0.231 ± 0.006^{ab}	0.240 ± 0.006^{c}
VCO_2 (L/min)	0.182 ± 0.005^{a}	0.189 ± 0.005^{ab}	0.200 ± 0.005^{c}

^{abc} Means not sharing the same superscript across rows are significantly different ($p<.0001$)
REE-Resting Energy Expediture
RQ-Respirtory Quotient
VO_2-Oxygen Consumption
VCO_2- Carbon Dioxide Production

Table 3: Mean, standard deviation, and range for select variables for resting condition (n=65)

	Mean ± SD	Range
REE (kcal/day)	1576.1 ± 308.2	1067.0 -2376.0
RQ (VCO_2/VO_2)	0.80 ± 0.042	0.63 - 0.89
VO_2 (L/min)	0.227 ± 0.044	0.155 - 0.341
VCO_2 (L/min)	0.182 ± 0.037	0.119 - 0.276
FIO_2	20.87 ± 0.037	20.80 - 21.00
FEO_2	20.04 ± 0.117	19.84 - 20.80
$FECO_2$	0.763 ± 0.052	0.63 - 0.88

REE-Resting Energy Expediture
RQ-Respirtory Quotient
VO_2-Oxygen Consumption
VCO_2- Carbon Dioxide Production
FIO_2-Fraction of Inspired Oxygen
FEO_2-Fraction of Oxygen in Expired Air
$FECO_2$-Fraction of Carbon Dioxide in Expired Air

Table 4: Mean, standard deviation, and range for select variables for music condition (n=65)

	Mean ± SD	Range
REE (kcal/day)	1603.7 ± 313.6	1066.0 - 2349.0
RQ (VCO_2/VO_2)	0.82 ± 0.04	0.70 - 0.92
VO_2 (L/min)	0.231 ± 0.045	0.154 - 0.336
VCO_2 (L/min)	0.188 ± 0.038	0.121 - 0.276
FIO_2	20.87 ± 0.035	20.80 - 21.00
FEO_2	20.04 ± 0.065	19.84 - 20.26
$FECO_2$	0.769 ± 0.050	0.59 - 0.87

REE-Resting Energy Expediture
RQ-Respirtory Quotient
VO_2-Oxygen Consumption
VCO_2- Carbon Dioxide Production
FIO_2-Fraction of Inspired Oxygen
FEO_2-Fraction of Oxygen in Expired Air
$FECO_2$-Fraction of Carbon Dioxide in Expired Air

Table 5: Mean, standard deviation, and range for select variables for reading condition (n=65)

	Mean ± SD	Range
REE (kcal/day)	1678.8 ± 331.9	1164.0 - 2422.0
RQ (VCO_2/VO_2)	0.82 ± 0.037	0.69 - 0.91
VO_2 (L/min)	0.240 ± 0.047	0.166 - 0.351
VCO_2 (L/min)	0.197 ± 0.039	0.137 - 0.275
FIO_2	20.87 ± 0.034	20.80 - 21.00
FEO_2	20.01 ± 0.070	19.83 - 20.17
$FECO_2$	0.763 ± 0.052	0.63 - 0.90

REE-Resting Energy Expediture
RQ-Respirtory Quotient
VO_2-Oxygen Consumption
VCO_2- Carbon Dioxide Production
FIO_2-Fraction of Inspired Oxygen
FEO_2-Fraction of Oxygen in Expired Air
$FECO_2$-Fraction of Carbon Dioxide in Expired Air

APPENDIX E

Consent to be a Research Subject

Introduction

This research study is being conducted at Brigham Young University by Blaire Snell, RD and Susan Fullmer PhD, RD to determine the effects of relaxing music and reading with an electronic tablet or a magazine on resting energy expenditure (REE). You are invited to participate in this study if you meet the following criteria:

Criteria for participation:

- 18 to 50 years of age
- Stable weight (defined as no fluctuation in weight greater than 5 lb (2.3 kg) over the previous six months)
- Otherwise healthy

Conditions that exclude study participation:

- Thyroid dysfunction
- Pregnancy or lactation
- Medications known to affect REE

Procedures

If you agree to participate in this research study, you will be asked to come to the research lab for two separate visits. The visits will take place in the Nutrition Assessment Lab, S-288 of the Eyring Science Center.

On the first visit we will obtain your height and weight and orient you to the study. This visit will last 20-30 minutes. To get a more accurate weight measurement, light clothing during this visit is encouraged.

On the second visit, your metabolic rate will be measured three times, each measurement taking 25 minutes. Your metabolic rate will be measured using an indirect calorimeter which collects oxygen consumption and carbon dioxide production through a clear canopy that is placed over your head. Indirect calorimetry testing is done under the following conditions:

- early morning (between 5:00 am and 8:00 am)
- no food or drink for 12 hours prior to test
- no caffeine intake 24 hour prior to test
- no exercise for 12 hours prior to test
- unshowered (you may shower the night before)

When you arrive for the test you will be seated in a reclining chair for approximately 30 minutes before the measurements begin. Your metabolic rate will then be measured under three different conditions for 25 minutes each. The three conditions are resting, listening to relaxing music, and reading either an electronic tablet or magazine. The order in which they will be administered will be randomized. Regular clothing may be worn during this visit. This visit should take no longer than 2 hours.

You may bring your own relaxing music or choose from a playlist. If you choose your own music you will be asked to bring it in at the first visit. Music may be played on your own device or an electronic tablet that will be provided. Headphones will be provided by the researchers. For the reading portion of the test, you may choose to read either a magazine or read on an electronic tablet, either your own or the one provided. If you bring your own electronic device please be sure it is fully charged and in proper working order prior to the test.

Risks/Discomforts

There are minimal risks for participation in this study. Some individuals may experience mild claustrophobia under the canopy. If this does occur the test will be stopped immediately. You will then have the option of continuing with the test or withdrawing from the study.

Compensation

Participants will not receive any monetary compensation in association with participating in this research and there is no financial cost to you as a participant in this study.

Benefits

Participants will receive a report of their REE and have the opportunity to discuss it with a Registered Dietitian. It is anticipated that this study will define acceptable protocols for measuring REE in research and clinical settings.

Confidentiality

Strict confidentiality will be maintained. No individual identifying information will be disclosed. Your name will be on file for contact purposes only. All identifying references will be removed and replaced by control numbers. It is the intention of the investigators to report and publish the mean values and other statistical reports of all subjects. Your personal information and the results of your tests will not be distributed without your written permission.

Participation

Participation in this research study is voluntary. You have the right to withdraw at any time or refuse to participate entirely.

Questions about the Research

If you have questions regarding this research study, you may contact Blaire Snell, RD at (801) 369-4973, blaire717@gmail.com, or Susan Fullmer, PhD, RD, CD, S-227 ESC, Brigham Young University, Provo, Utah, (801) 422-3349, susan_fullmer@byu.edu.

If you have questions regarding your rights as a participant in a research project you may contact an IRB Administrator at (801) 422-1461; A-285 ASB, Brigham Young University, Provo, UT 84602; irb@byu.edu.

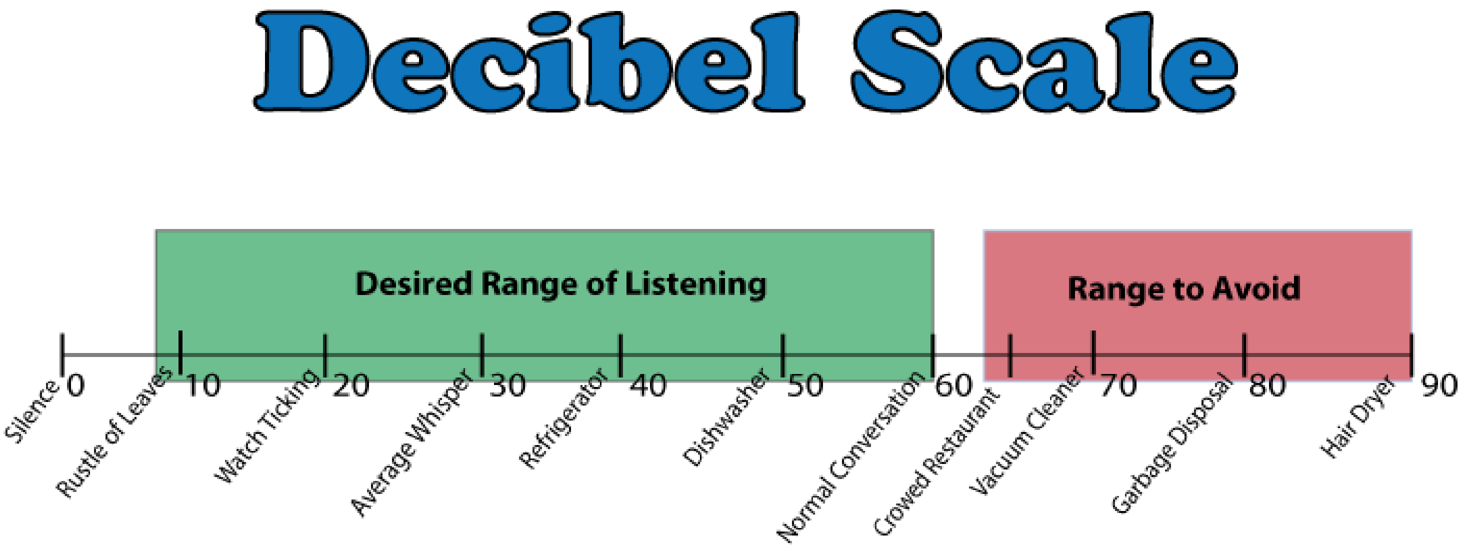
Statement of Consent

I, ____, have read, understood, and received a copy of the above consent form and desire of my own free will to participate in this study.

____   __________________

Participant Signature   Date

Decibel Scale



WANTED

Volunteers for a Resting Energy Expenditure Research Study

Have you ever wondered what your metabolic rate is?
If you are:

- **between the ages of 18-50 years old**
- **have had a stable weight (+/- 5 lbs) over the past six months**
- **are not pregnant or lactating**
- **not currently taking medication that would affect your metabolism**

You could qualify for a study on campus!!

There is no financial cost to you. Participation will include two separate visits to the Nutrition Assessment Lab, S-288 of the Eyring Science Center. Total time commitment will be 2 hours over 2 days. You will receive a print out of your resting metabolic rate and the opportunity to discuss it with a Registered Dietitian.

If interested please contact Blaire Snell, RD at metabolicstudy13@byu.edu

Department of Nutrition, Dietetics & Food Science