1-1-2014

Desk Jockey: A Device To Increase Non-Exercise Activity Thermogenesis (neat) In Adults

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DESK JOCKEY: A DEVICE TO INCREASE NON-EXERCISE ACTIVITY THERMOGENESIS (NEAT) IN ADULTS

by

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THESIS

Submitted to the Graduate School

of Wayne State University,

Detroit, Michigan

in partical fulfillment of the requirements

for the degree of

MASTER OF SCIENCE

2014

MAJOR: NUTRITION AND FOOD SCIENCE

Approved by:

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Advisor Date

DEDICATION

This thesis is dedicated to Dr. K-L, Catherine Jen and Dr. Hermann-J Engels for the support and guidance that they provided during the time of my study; and to Michael Scarchilli from Desk Jockey LLC for his great design of Desk Jockey and all the assistance he provided.

In addition, I would like to dedicate this thesis to my parents Jian Tang and Tiandi Jiang for their continuous love, care and encouragement to believe in myself.

ACKNOWLEDGEMENTS

I would like to acknowledge the following people for their support and assistance.

Advisor: Dr. K-L Catherine Jen

Committee Members: Dr. Ahmad Heydari and Dr. Kequan Zhou

Research Team: Michael Scarchilli, Yulyu Yeh, Jaipal Singh

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Introduction

According to population statistics from most countries, the computerization and industrialization of environment are associated with the increase of sedentary behaviors (SBs) (1). More than half of waking hours among Americans was sedentary (2), which have drawn considerable attention to study the SBs and their health consequences lately.

Metabolic Equivalent (MET) is used to describe the energy expenditure (EE) in physical activities. It is the ratio of working metabolic rate to resting metabolic rate. One MET refers to 1kcal/kg/hour, which roughly equals to the EE of sitting quietly. It also refers to the oxygen uptake in ml/kg/min, which is roughly equivalent to 3.5ml/kg/min oxygen uptake (3). In 2008, Pate et al defined the concept of SBs to extinguish them from light-intensity activities. The SBs have the EE within the rage of 1.0-1.5 METs and they include activities such as sitting, lying down, sleeping, watching television, using computer, and other forms of screen-based activities (4, 5). During last few years, most health- related scientific societies, especially in the cardiologic and metabolic areas, have made a series of recommendations for the public to avoid being sedentary and change lifestyle into active mode (6, 7). For instance, adults are recommended to accumulate at least thirty minutes of moderate-intensity physical activities preferably all days in a week, for the sake of health promotion and disease prevention (8). The recommendation is similar for older adults while the type and intensity of physical activity are adjusted based on personal health conditions (9). It has been reported by the World Health Organization (WHO) that more than 60% of the world’s population failed to accomplish this physical activity recommendation. Moreover, even those adults who met the recommended amount of physical activities still spend nine to ten hours sitting during the remaining time (10).

Increasing evidences have shown that SB is an independent risk factor for inducing varied health problems (4), such as overweight (11, 12), obesity (13), Type 2 diabetes (14-16), and mortality in adults (17).

According to the report from WHO, updated transportation mode, occupational and domestic activities along with insufficient accumulation of physical activities during leisure time are the major reasons that cause sedentary lifestyle (4). Moreover, numerous studies have compared the situation of SBs according to different societies, gender, age, socioeconomic and educational levels. Physical activity levels vary with different societies and sociodemographic groups. The activity levels are higher in Northern European countries when compared to the Mediterranean countries (18). One out of seven people in West Africa is reported as physically inactive (19). SBs also increase with age, both in adolescents and adults (19, 20). When compared between genders, women are more sedentary than men (18, 20, 21). Evidences also suggest that the levels of urbanization affect lifestyle. Changing diet style to high fat and high sugar and increasing sedentary occupations are the outcomes of urbanization; therefore, urban residents are more sedentary in comparison with rural residents (18, 20). In addition, adults with lower socioeconomic status (22, 23, 24) and educational level (18, 21) usually have more sedentary time.

WHO reported that obesity (individual with body mass index: BMI > 30 kg/m^2) is one of the most serious health problems in this century (4). The prevalence of obesity keeps rising around the world (25), and developing countries are also affected (4). Obese individuals are at high risk of cardiovascular disease and type 2 diabetes, hypertension, cancers and other diseases. The large portion of fat in the abdominal region is a more serious risk factor than the total excess weight per se or fat in the gluteofemoral region (26). The abdominal obesity and increased level of visceral fat are significantly associated with the risk of metabolic disease, defined as a constellation of metabolic abnormalities including glucose intolerance and insulin resistance (27).

The two major contributors to overweight and obesity are excessive dietary energy intake and physical inactivity. However, data have shown that SBs to be a more dominate power in producing overweight/obesity in recent years (28). Researches have shown that sedentary men and women have an increase in body weight, visceral fat and metabolic deterioration (29). Studies also reported that these health consequences of obesity could all be decreased if individuals start to engage in sufficient exercises (30). Therefore, obesity may be prevented or substantially reduced if individuals become more physically active and less sedentary.

Insulin resistance plays a vital role in several health conditions, such as obesity (31), hypertension (32), type 2 diabetes and cardiovascular diseases (33). A research studying three thousand Iranian adults showed that lower level of physical activity would significantly increase insulin resistance. Both low intensity and short duration of the physical activity would significantly increase insulin resistance. In addition, the duration of SBs was significantly higher in individuals with higher insulin resistance in both genders (34). Through increasing physical activity, the mitochondrial oxidative capacity in skeletal muscle can improve insulin action by decreasing the accumulation of incompletely oxidized fatty acids (29). Moreover, lacking physical activity and having excess weight are two crucial determinants of metabolic syndrome. It has been reported that in addition to increasing physical activity, reducing sedentary time such as using a computer for less than 1 hr/day, the prevalence of the metabolic syndrome could be potentially decreased by 30% - 35% in American adults (35). A research based on a representative sample of American individuals has reported that the prevalence of metabolic syndrome would be increased by 30%-35% when individuals spent more than four hours in SBs compared to those spent less than one hour per day (36). Similar evidences also showed that higher levels of SBs are significantly associated with increasing cardiometabolic risks, such as unhealthy levels of total cholesterol, HDL cholesterol, triglycerides, non-fasting blood glucose and systolic blood pressure (37).

In addition, being sedentary without sufficient physical activity has already been demonstrated as an important factor affecting bone mineral density. A research studying young Chinese women showed that being physically inactive could increase the risk of lower bone mineral density in spine and hip. This study also suggested that reducing sedentary lifestyle would maximize bone mass and reduce the risk of osteoporosis in later life (38). Furthermore, low level of physical activity and long-time sitting as watching television are associated with poorer muscular fitness among young adults (39).

Long sedentary time is also detrimental even when the adults are physically active. Four thousand active adults with more than 2.5 hr/week of moderate- to vigorous-intensity physical activity were studied to examine the metabolic variables. Significant and detrimental associations were found between sedentary time and observations including waist circumference, systolic blood pressure and 2-hr post-prandial plasma glucose in both genders. The associations were found stronger in women regarding triglycerides and HDL-cholesterol levels (10). Therefore, the American College of Sports Medicine (ACSM) recommended that frequent and short bouts of physical activity should be added between periods of SB in order to gain healthy benefits (40).

In the last two decades, the working mode in developed countries has become computer-based in offices (41). This change of mode has made office workers (OWs) spend most of their workdays sitting at the desk (42). In addition, the obese individuals tend to be seated two hours more than lean individuals in their regular days (43). Epidemiologic observations showed that a man having a job requires long sitting hours would have a 2 fold increase in the risk of cardiovascular disease when compared to having a job requires physical activities (44). Therefore, it is urgent to encourage OWs engaging in physical activities to break down continuous sedentary time and increase EE.

Energy expenditure has three components: basal metabolic rate (BMR), thermic effect of food (TEF) and physical activity. The BMR accounts for about 60% of total EE of a sedentary individual. Due to the fact that lean body mass is positively associated with BMR, around 73% of BMR is determined by lean body mass of the individual. The TEF covers approximately 10% of the total EE. It accounts for the EE related to ingestion, digestion, absorption of food and the conversion into intermediary metabolites. The physical activity is responsible for the rest of the EE (45) and is the component with the large individual variability and is totally self-controlled.

The EE related to physical activity includes purposeful exercise and non-exercise activity thermogenesis (NEAT) (11). The purposeful exercise is defined as “bodily exertion for the sake of developing and maintaining physical fitness”. Engaging in sports, exercising in the gym or club are examples of purposeful exercise (46). However, only 20% of Americans are exercise regularly (45). The majority of public do not engage in exercise for the purpose of fitness and thus the EE from purposeful activity is not a significant contributor to EE (11). Therefore, the NEAT accounts for the major variance of EE in daily living (45), ranging from around 15% of total EE among very sedentary individuals to more than 50% of EE among highly active individuals (47). NEAT is the EE of all physical activity except for volitional sporting-like exercise (11), including EE of activities such as occupational and leisure activities, walking, dancing, standing, sitting, talking, toe-tapping, playing music instruments and shopping (47).

There are a variety of factors that could affect NEAT levels among individuals. The most important variance is associated with different occupation. Sedentary OWs have a mean BMR of 1500 kcal/day while individuals working in construction or agriculture could increase the NEAT by 1200 kcal/day (11). The environment also plays a role in affecting NEAT. Urbanization has been proved to be associated with lower level of physical activity. Services for optimizing convenience and the expense of necessitating locomotion in developed countries have encouraged sedentary trend. NEAT can also be affected by age, gender and body compositions. Studies have demonstrated that physical activity declines with aging in both men and women (48). Gender has a more subtle effect on physical activity. Male and female adults in the United States were reported to have similar levels of physical activity; however, males from Canada, Australia and England were reported being 1.5 to 3 times more active than females (49). Moreover, there have been sufficient evidences showing that lean individuals have higher levels of physical activity than overweight individuals, across all ages, genders and ethnic groups (50).

Plenty of researches aimed at increasing purposeful exercise have demonstrated that these types of exercise, such as walking and using treadmills, to be inconvenient and unrealistic for OWs, due to disturbing regular work, requiring large office space or requiring a high cost of purchasing facilities/equipment (51). Instead, attention should be paid to improve NEAT in OWs, for their long sitting-hours, regular deskwork and limited office space. Therefore, increasing physical activity that would not disturb working would be more feasible and efficient for the OWs. This research studied a portable and inexpensive device that was designed to help OWs reverse the SB and increase EE during the time working at the desk. It requires the OWs to be seated and pedal their feet backward and forward like walking without disturbing regular deskwork. The aim of this research was to investigate whether using the DJ by long sitting-time OWs could significantly improve NEAT so that EE and HR could be increased in a simulated office environment.

Materials and Methods

Subjects

After the research was approved by Institutional Review Board (IRB) of Wayne State University, the study flyers (Appendix A) were posted on the Wayne State campus and Wayne State Facebook website. Participants between 18 and 70 years of age were recruited and contacted through emails. Pregnant or nursing women and individuals with joint/hip problems, diabetes, cardiovascular disease and hypertension were excluded. Sixteen participants were recruited into this study. Three participants withdrew in the middle of research due to different expectations and limited available time.

Every participant was led to the Exercise Physiology Laboratory located at the College of Pharmacy and Health Sciences (EACPHS) in Wayne State University. Study was conducted individually and privately, one participant at a time. The consent form (Appendix B) was explained to each participant, and was signed by the participant after reading and questioning. Height (portable stadiometer, Model 242, Seca Corp, Hanover, MD) and body weight (Model 644, Seca Corp.) of participant were measured for three times and the average values were used. At the beginning of the study, the participant would first sit comfortably on an office chair, put their feet on the pedals and get used to the environment. Then the indirect calorimeter's mask and nose clips were placed on the participant's face to collect oxygen consumption and carbon dioxide production data. Every participant would randomly test five different sessions in two days. Each session was divided into ten minutes of sitting in a chair without any leg movement to achieve a resting state, twenty minutes of pedaling and twenty minutes of recovery. Data were collected over the fifty minutes in each session.

Equipment

1. The Desk Jockey (Desk Jockey LLC, Detroit, MI)

The Desk Jockey (DJ) is a simple, portable and convenient device designed by Desk Jockey LLC (Detroit, MI. Figure 1). It contains 2 pedals spaced with 15° angle rather than parallel to be ergonomic and simulating the natural feet angle while walking. The resistance level of this device was determined by the weight added under the pedals. It was placed in the Exercise Physiology Lab in EACPHS building. The appropriate resistance level was modified first according to the session order of each participant. The heavier the weight added, the higher the resistance. Then the DJ was placed on the floor directly in front of the participant's chair. It was adjusted close to the participant for a safe and comfortable use. The participant then placed his/her feet firmly over the center of the foot pedals and both feet were secured with a fasten band. Then the participant cycled the foot pedals forward and backward, so that the right and left pedals were moved in the opposite direction from each other, as in the walking motion. This walking motion covered the entire span of track from the front to the back. The speed of pedaling was determined by the session order of the participant. Each participant was instructed to pedal according to the speed of a metronome that was placed adjacent to the DJ so the participant could easily follow its motion.

2. Indirect calorimeter: TrueMax 2400 computerized metabolic systems (ParvoMedics, Salt Lake City, UT)

The indirect calorimeter (Figure 2) was housed in the Exercise Physiology Lab in EACPHS Building. It calculates the heat produced by measuring the production of carbon dioxide and the consumption of oxygen. After the calibration, each participant was fitted with a mask with a mouthpiece and nose clip. Through this mask and nose clip, the volume of oxygen consumed and carbon dioxide exhaled by the participant would all be measured through the collecting tube connected to the calorimeter. Then the system would calculate and save the results of METs and EE. The indirect calorimeter was calibrated two times per day, in the morning and afternoon, with the standard room air concentration of 20.94 % oxygen and 0.03% carbon dioxide. Data were collected in the environment with temperature 22.0 ± 0.5 ^{0}C and barometric pressure 746.0 ± 2.1 mmHg. This calibration took about 15 min to complete.

3. Pulse Oximeter: CMS50E (FaceLake, Lake Bluff, IL)

A fingertip Pulse Oximeter was used to measure the pulse rate (beats per minute, BPM) during the entire data collection periods. It was a non-invasive device with the attachment to the index finger.

Methods

Based on the pedaling resistance and frequency, 5 sessions were administered to each participant in random orders:

1. Total sedentary (TS)

After the participant was seated in the chair for acclimatization for 10 min, the mask and nose clip were placed on the face of participant and the indirect calorimeter started to collect O_2 consumption and CO_2 production data for 50 min. The participant was required to put both feet on the ground for the first 10 min and then put both feet on the pedals of the DJ without any movement for 20 min. After that, the participant put both feet on the ground for the last 20 min. During the 50 min testing session, all the participants were asked to engage in activities such as reading, writing or working with the computer.

2. Low frequency, low resistance (LFLR)

After acclimatization, the participant sat down at the desk and put on the mask for the indirect calorimeter to collect all the data. The participant started to put both feet on the pedals for the first 10 min to collect the baseline data. Then the participant was instructed to pedal the DJ for 20 min at low resistance (77.3 ounces) at the frequency of 112 beats per min following the motion of a metronome. The participant then kept both feet on the ground for the remaining 20 min. The indirect calorimeter was stopped once the participant finished the 50 min session.

3. Low frequency, high resistance (LFHR)

The participant followed the same procedure as the session “LFLR” except that the pedal resistance was increased by attaching higher weight to the pedals (high resistance: 114.3 ounces).

4. High frequency, low resistance (HFLR)

The participant followed the same procedure as the session “LFLR” except for the frequency was raised to 152 beats per min.

5. High frequency, high resistance (HFHR)

The participant followed the same procedure as the session “LFLR” except for the frequency was raised to 152 beats per min and the resistance was increased to the high level of 114.3 ounces.

Statistical analysis

All the data from the five resting and pedaling sessions were entered into the computer and were analyzed by the SPSS 22.0 statistics software (SPSS, Armonk, NY). After the preliminary examination of the data collected from 5 session, it was observed that all the active sessions had significantly higher EE and METs than the resting session, a 2 (frequency, high and low) by 2 (resistance, high and low) factorial design with repeated measures were used to analyze the main effects of frequency and resistance, as well as their interactions on METs, HRs and EE. Participants were also classified into two groups according to BMI to find out whether

METS, HRs and EE were significantly different between healthy weight and overweight/obese groups. The correlations were calculated to identify whether METs and EE would be influenced by BMI or age. Significance was considered at $p < 0.05$.

Results

Of the 13 participants completed all 5 data collection sessions, seven participants were males and six were females. The mean body weight of the participants was 73.1 ± 19.2 kg, and the mean height was 1.69 ± 0.1 m. Eight participants had a healthy BMI (within the range of 18.5 – 24.9kg/m^2), 3 had the BMI within the range of overweight (BMI: 25.0 - 29.9 kg/m^2) and 2 had the BMI within the range of obese (BMI ≥ 30 kg/m^2). The mean age of the participants was 25 ± 7 yr, and the mean sitting hours/day was 8.6 ± 3 hr based on self-report. All the participants were classified into two groups: healthy weight group (BMI < 25 kg/m^2), and overweight/obese group (BMI ≥ 25 kg/m^2). The DJ was tolerated well by all participants; no falls, slips or injuries reported during the experiment periods.

The METs increased significantly during the pedaling periods when compared to the first 10 min resting period (Figure 3), regardless of whether the frequency and resistance were high or low: the METs increased by 0.9 ± 0.3, 0.9 ± 0.3, 1.3 ± 0.5 in the sessions of LFLR, LFHR and HFLR ($p < 0.01$) and 1.5 ± 0.4 in the session of HFHR ($p = 0.054$). During the pedaling periods, the METs were still very low (2.5 ± 0.6) and therefore were considered as in the NEAT range. The HRs was 96 ± 9 BPM when they reached the highest point during pedaling activities in all pedaling sessions. Both METs and HRs were still higher during the first 10 min recovery period than that of the rest states ($p<0.05$). When compared between two frequency and two resistance levels during pedaling periods, results showed that increasing frequency had a significant enhancement on both METs and HRs ($p < 0.01$). In addition, raising the level of resistance also made significant increase in METs while it made no significant difference in HRs. Interaction of frequency and resistance was found in effecting METs ($p < 0.05$) while no interaction was showed in HRs. This significant interaction indicated that higher frequency level could significantly increase METs at low resistance while no difference between two frequency levels could be found at high resistance.

As shown in Figure 4, the EE was up to 99 ± 18 kcal/50min when participants finished the session of HFHR while the EE during resting session was only 64 ± 19 kcal. The EE of all the participants was raised significantly during the pedaling sessions of LFLR, LFHR and HFLR above the rest state (13.7 ± 3.3): 9.8 ± 3.5, 10.2 ± 2.8, 13.7 ± 5.4, ($p < 0.05$); while EE increased by 16.2 ± 4.7 during the HFHR session ($p = 0.054$). During 10 min recovery after pedaling, the EE was still significantly higher than the rest state ($p < 0.01$). Similar to the findings of HRs, raising the level of frequency increased the EE significantly ($p < 0.01$) during the pedaling states while no difference was found by raising resistance levels. Moreover, no interaction was discovered between frequency and resistance in affecting EE.

There were significant positive correlations between BMI and EE in the sessions of TS, LFLR, LFHR and HRLF, p's < 0.01 (Figure 5A). Regardless of high or low levels of frequencies and resistances, participants with higher BMI had larger energy expenditure when compared to participants with healthy BMI. The results also showed that subjects with similar BMIs (19.6 vs. 19.1) had quite different levels of EE (30 kcal vs. 61 kcal). And similar findings were discovered when testing the correlations between BMI and METs after pedaling for 20min (Figure 5B). Significant positive correlations were found in the sessions of TS, LFLR, LFHR and HRLF ($p < 0.05$) while no correlation was found in the session of HFHR. In addition, there were no correlations discovered between age and METs or age and EE.

As shown in Figure 6, there were significantly different METs between the groups of lean/healthy weight and overweight/obese, not only at the sedentary state ($p < 0.01$), but also at the pedaling state of LFLR, LFHR and HFLR (p's < 0.05). Moreover, the overweight/obese group also had a significant higher EE when compared to the healthy weight group in all five sessions (p's < 0.05).

Discussion

It is the fact that the development of economy and social environment has made changes in communication, transportation and especially workplace productivity (52). People are spending the majority of waking hours at work, mostly working sedentarily behind computers (53). Nutritional excess and lower level of physical activity have produced energy imbalance resulting in obesity and other chronic diseases (54). Therefore, it is urgent to realize that the prolonged sedentary time at work is unhealthy and should be reduced. The DJ we studied was a portable, convenient and inexpensive device that aimed at reducing sedentary behaviors among OWs and increasing NEAT. Our results demonstrated that pedaling on DJ for twenty minutes could increase NEAT up to 70 kcal/20 min while sitting for twenty minutes was only around 25 kcal. More importantly, the NEAT is still higher than sedentary state 10 min after pedaling has stopped. Future studies should lengthen the pedaling time and examine the post-pedaling EE recovery pattern. It is expected when the pedaling time is lengthened, the EE during the recovery time will be increased too. This may further increase EE and improve body weight status and other metabolic parameters.

In order to study the effects of physical activities on human health, most researches have focused on the effects of moderate-to-vigorous physical activities (3 to 8 METs), such as brisk walking or running (4). However, regular desk job and limited office space make it not realistic to perform any moderate-to-vigorous physical activities during work time in the office. In addition, increasing physical activities alone is not enough for achieving health benefits. Long and continuous sitting and using computers still have significantly negative effects even when OWs have done enough purposeful exercises everyday (10). Instead, enhancing short and frequent bouts of physical activities during working hours is more beneficial for OWs as ACSM has recommended (40). Therefore, this research was designed to study the impact of low-intensity physical activity on NEAT with the consideration of OWs' working environment. Once an individual starts walking, even the speed as low as 1 mile/hr, the METS could be doubled. When increase the walk speed to 2 miles/hr, the raised METs could burn 150 – 200 kcal/hr while the resting state is only 20 kcal/hr (55). The study of using DJ also provided supportive evidences. When pedaling with the DJ, the METs of the participants were increased significantly in each session. This low-intensity activity could significantly raise METs and increase EE when compared to sitting; moreover, the NEAT could be increased not only during pedaling, but also after the cessation of activity. Results showed that through pedaling on the DJ, the distances traveled would be approximately 1.54 mile/hr at low pedaling speed and 2.09 mile/hr at high pedaling speed. The EE was 47 ± 11kcal/20min at low speed and 56 ± 10 kcal/20min at high speed (Figure 4B). Therefore, if the OWs would use the DJ for one hour, the EE could be increased up to 174 kcal to 198 kcal. This amount of energy was similar to the amount if walking at the speed of 2 miles/hr; moreover, using DJ during sitting time won't disturb deskwork when compared to walking.

Previous researches have suggested that METs could be affected by various abiotic and biotic factors, including age, gender, body mass, activity level, reproductive and absorptive state and behaviors (56, 57). Among all these factors, body mass accounts for the major variation (90%) that affects the METs (58, 59). Our study also showed that participants with higher BMI had significantly higher METs and EE when compared to participants with healthy BMI, both during sedentary state and pedaling sessions. Moreover, recent studies have demonstrated that METs of individuals of similar-sized could differ by over the order of magnitude (60). It was supported in our study that even with similar sizes, participants had different EEs. Therefore, using DJ in the office could be an effective way for OWs to decrease sedentary time and increase NEAT; and it could help overweight and obese OWs expend more energy than lean OWs. However, the EE expended during the pedaling could be varied significantly.

There was no evidence from this study indicating that age or gender was correlated to METs. More researches with large sample size should be performed to study the factors that affecting METs and EEs, thus individuals with varied physical conditions could use specific methods to increase NEAT efficiently.

This study also tested the effects of different frequencies (112 beats/min vs 152 beats/min) and resistances (77.3 oz. vs 114.3 oz.) on increasing NEAT. As Figure 3 and Figure 4 demonstrated, even though both frequency and resistance affected METs, raising frequency is more effective than raising resistance in elevating HR and EE. Therefore, when using DJ to increase NEAT, choose a higher pedaling speed would help OWs boost EE more than adding resistance to pedals. One possible reason that resistance did not contribute significantly to increase HRs and EEs may be due to the fact that the high resistance was too high for some participants to handle, especially at a higher frequency. As a result, they may not travel the entire length of the track. Further studies determining the optimal resistance level are warranted.

A recent research compared the effect of diet and diet-plus-exercise on BMR among obese participants. The results showed that the additional exercise not only increased METs significantly but also maintained the muscle mass of the participants (61). Further research should be conducted to study the long-term effects of using DJ on NEAT, body weight and composition by adjusting frequency or resistance.

When analyzing data collected from five different sessions, significant correlations between BMI and EE were discovered in all four sessions except for session HFHR (Figure 5). The METs of overweight/obese group in HFHR session were unexpectedly low and were not significantly different from those of the lean/healthy weight group (Figure 6). This could be the result that some participants, especially overweight and obese individuals, were not able to follow the high frequency with high resistance level at the same time. Thus, they might not move the pedals the entire length of the tracks. It also is possible that the mask or nose clip was not placed tightly on the participant's face due to the size issue, or the breathing tube connected to the mask was loose during the testing process. Therefore, this set of data cannot reflect the volumes of oxygen and carbon dioxide of the participant properly and correctly. Through increase of sample size or adjusting the size of mask and nose clips, such errors could be avoided and thus the METs and EE of all the sessions from two groups could be truly representative. Moreover, the range of age could be expanded to discover the effect of NEAT on adults of varied age range. Various frequencies could be adjusted for best effects and comfort.

Conclusion

Using DJ in the office is an efficient way to increase NEAT and EEs among adults, not only during pedaling process but also during ten minutes after the cessation of pedaling. This portable and convenient device could reduce sedentary behaviors of OWs and consequently enhance EE through low-METs activities. More importantly, the usage of DJ under the desk would not disturb OWs' regular deskwork, which could contribute to the efficiency of working and expending energy at the same time. Further researches should investigate the long-term benefits of using DJ based on large sample size with various frequencies and long duration of using DJ, as well as the metabolic changes associated with using the DJ.

Figure 1: The picture of Desk Jockey

Figure 2: The picture of Indirect Calorimeter

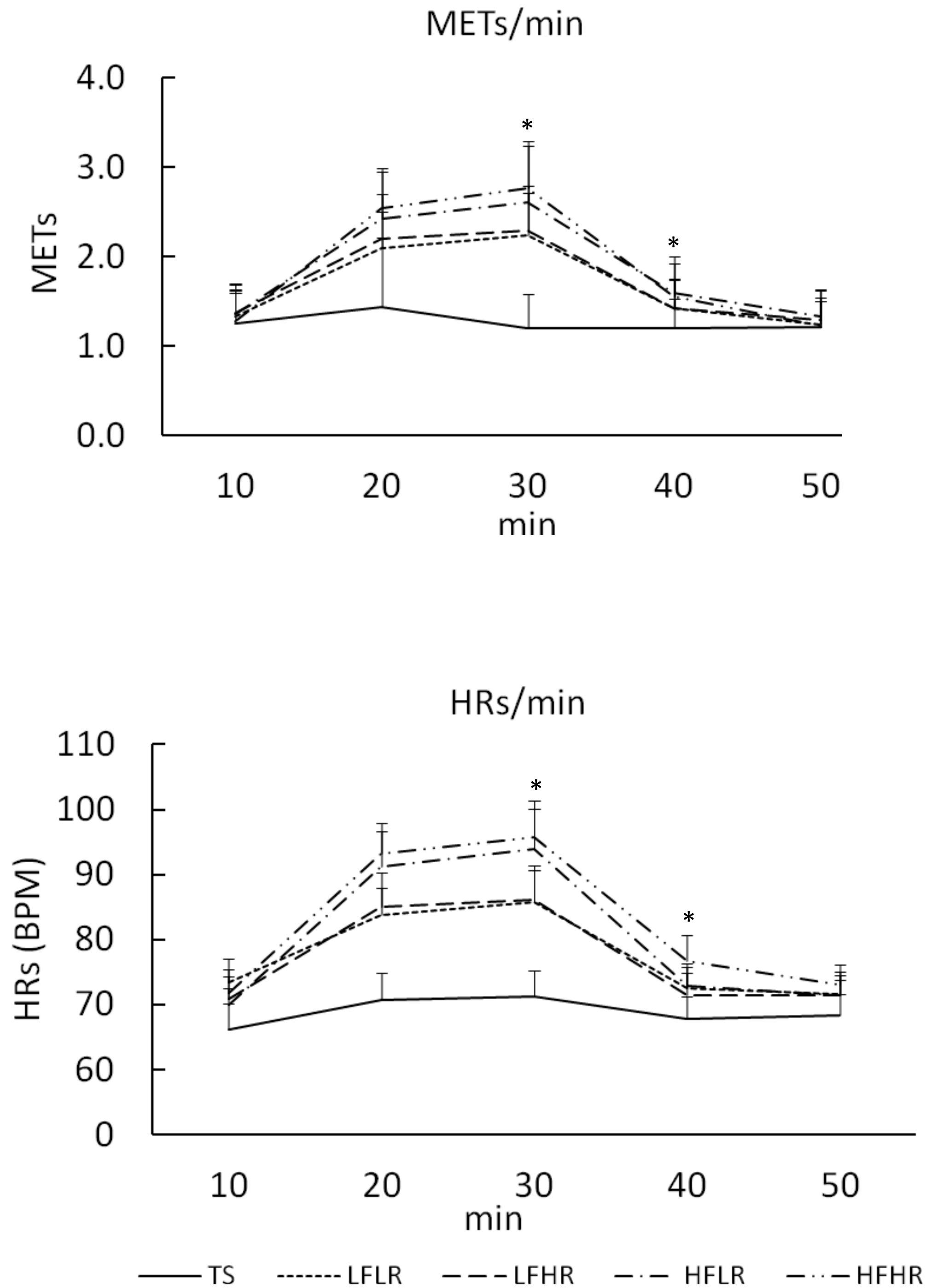

Figure 3. METs and HRs over the 50 min data collection period during five sessions METs increased significantly during pedaling periods when compared to the resting periods in each session. Data are expressed as mean ± SD.

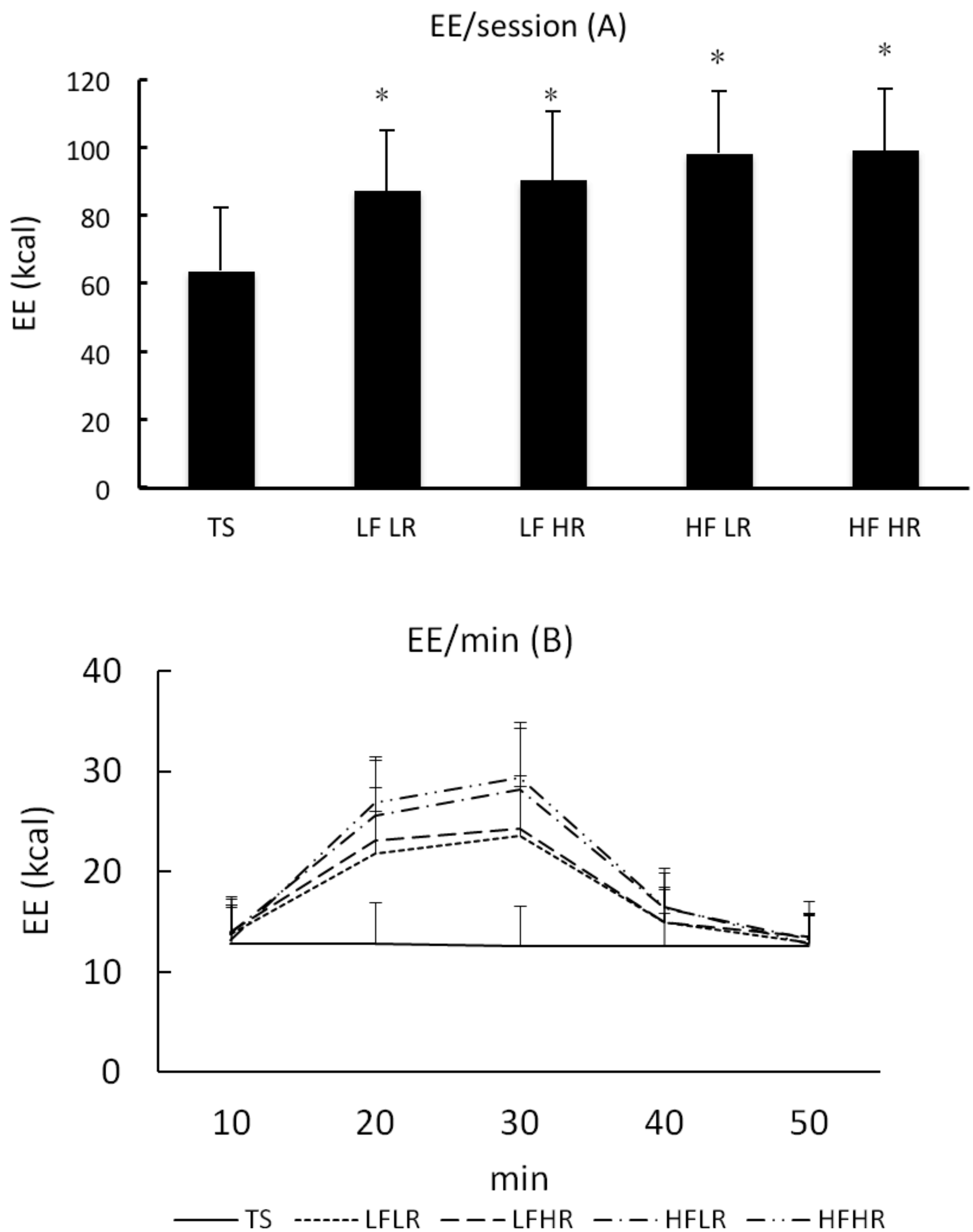

Figure 4. Energy expenditure during the five sessions

Figure 4A showed the means of EE among all participants during the entire 50 min sessions; figure 4B showed the means of EE over the 50 min data collection period during five sessions (mean ± SD).

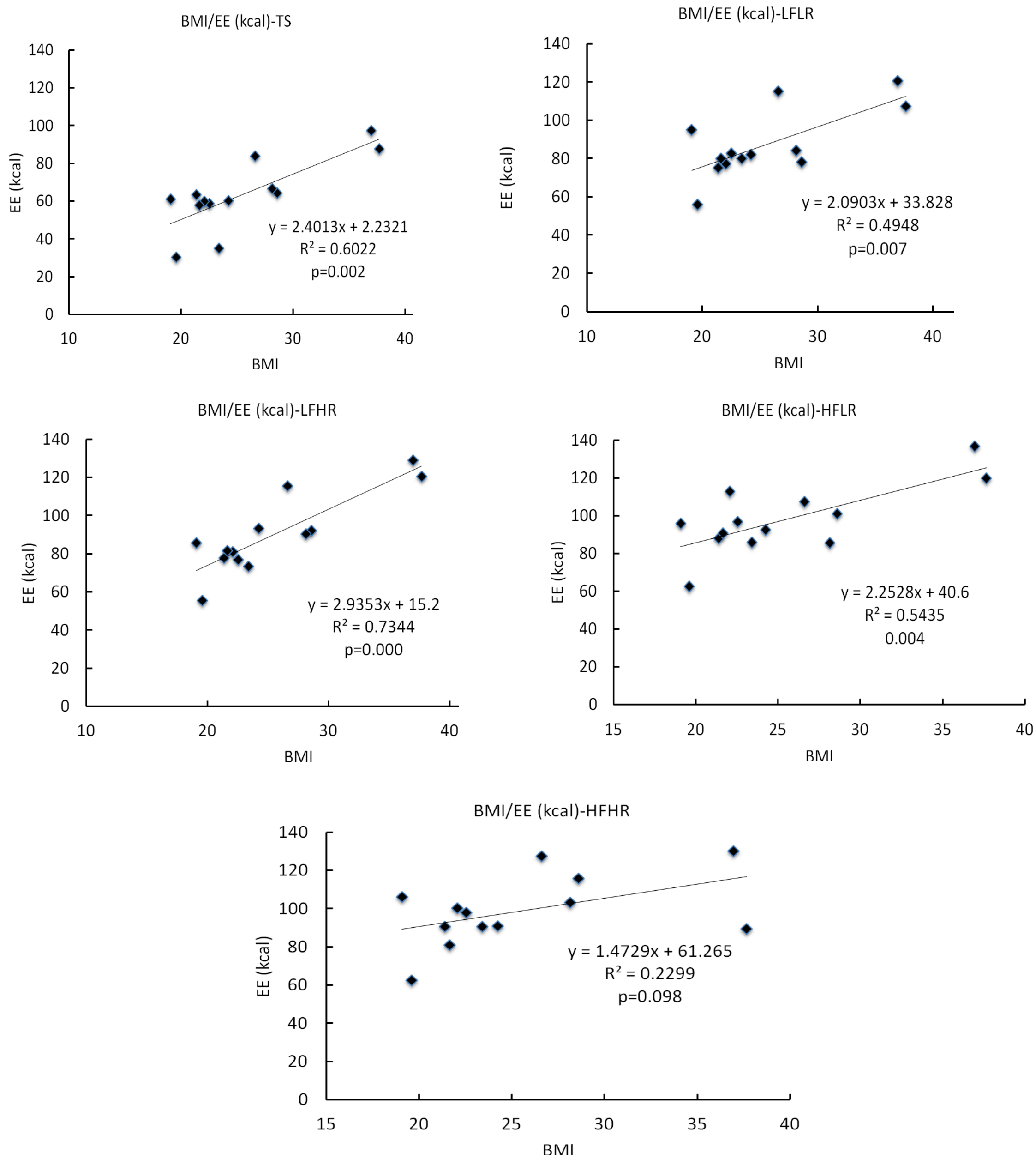

Figure 5A. The relationship between BMI and Energy Expenditure for the five sessions

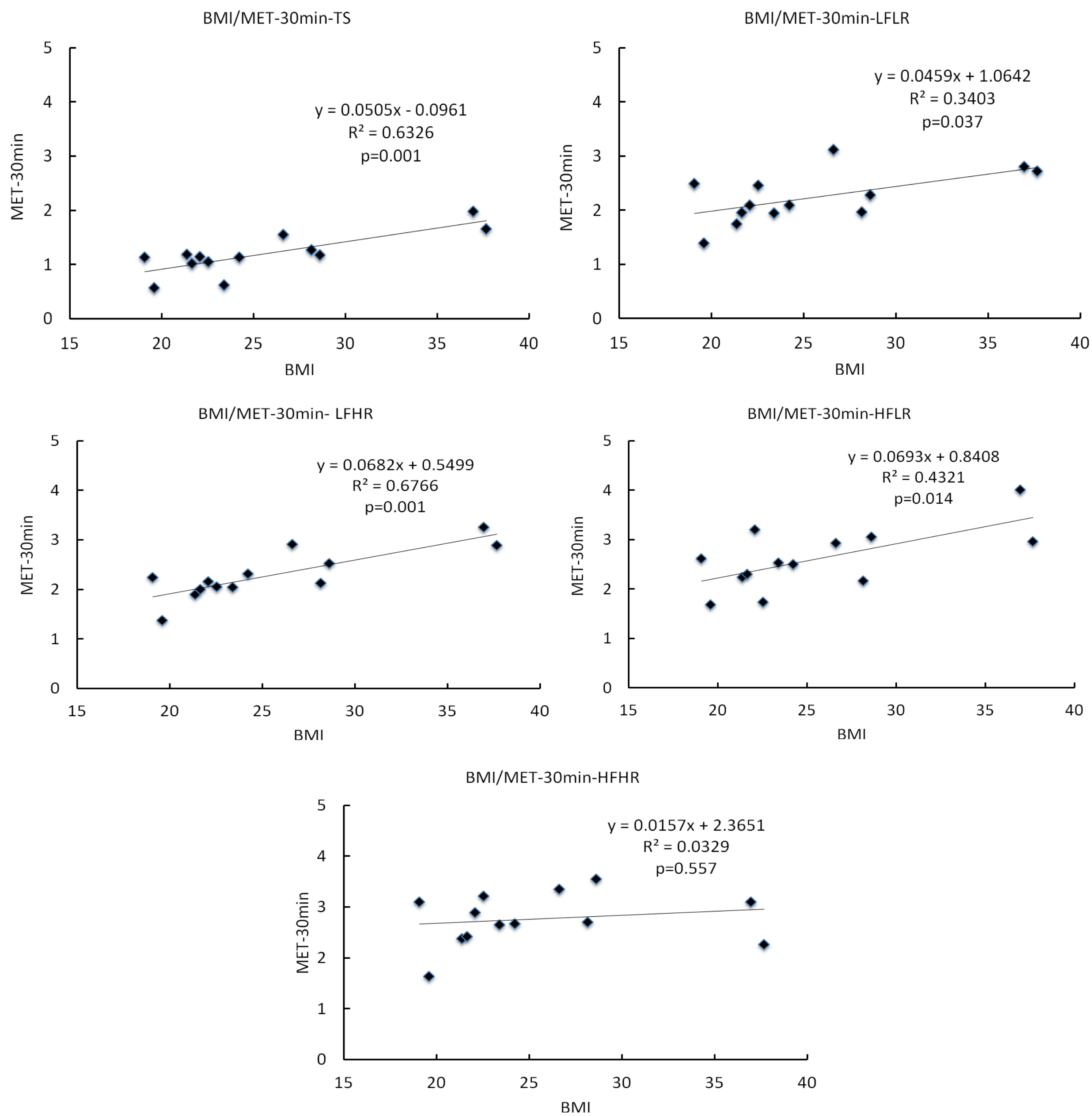

Figure 5B. The relationship between BMI and METs after 20min pedaling in five sessions

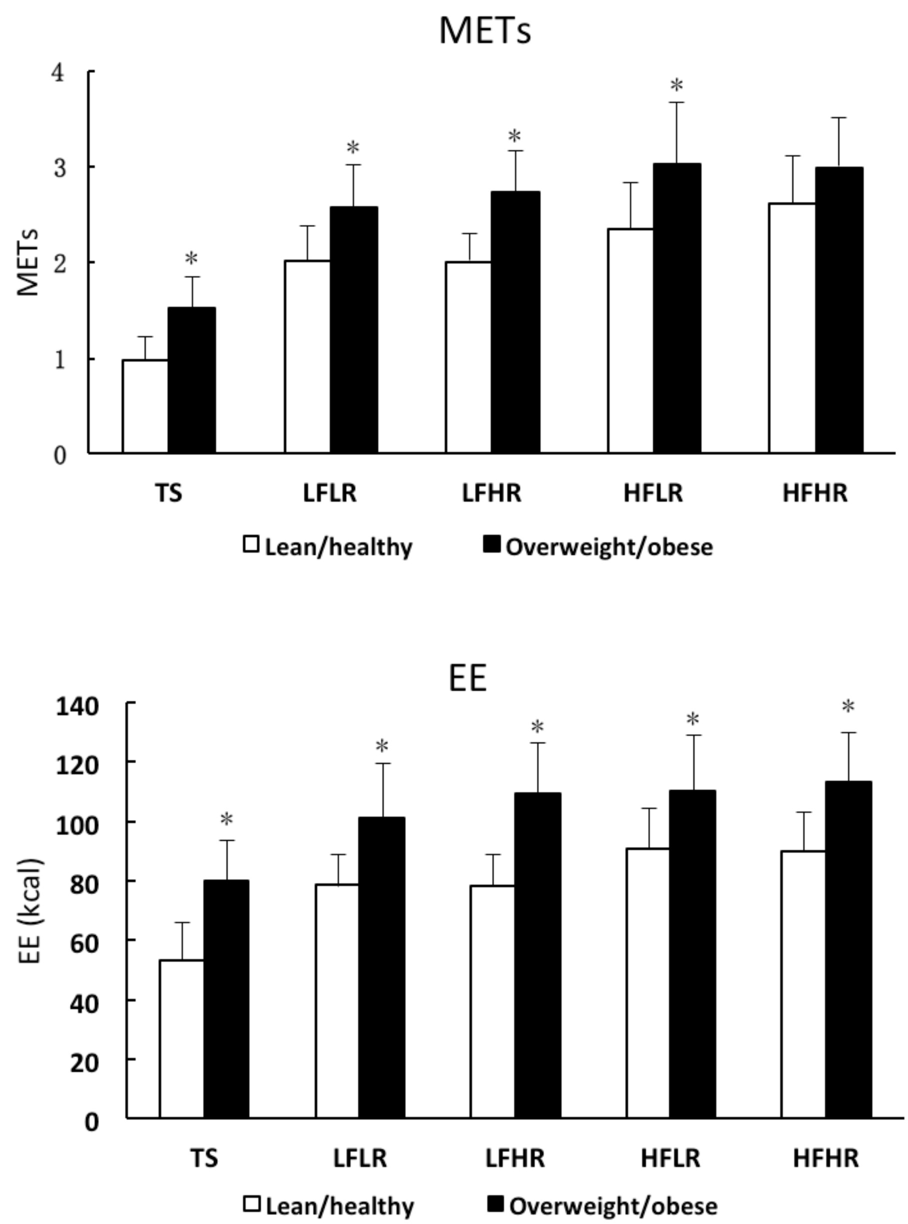

Figure 6. Comparison of METs and EE between lean/healthy weight and overweight/obese groups among all the five sessions

METs were compared during 20 - 30min of each session; EE represents the energy expenditure for the entire 50 min sessions (mean ± SD).

Appendix A

Volunteers Wanted
For
Nutrition Research Study

Volunteers will be required to:

Come to Exercise Lab located in EACPHS Building
For five 1-hr sessions
Be fitted with a mouth piece to measure metabolic rates
while sitting and pedaling a device that mimics walking

Benefits:

Free metabolic rate measurements
Compensation for participants!

If you are:

Between 18 and 70 years of age
Non-pregnant or Nursing

Please contact
Dr. Cathy Jen at (313) 577-2500 or cjen@wayne.edu

Wayne State University
3009 Science Hall

APPROVAL PERIOD
MAR 14 '13 MAR 13 '14
WAYNE STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD

Appendix B

Research Informed Consent

Title of Study: Desk Jockey: A device to measure NEAT

Principal Investigator (PI): K-L. Catherine Jen, Ph.D.
Professor and Chair
Department of Nutrition and Food Science
Wayne State University

Sponsor: Desk Jockey LLC

When we say "you" in this consent form, we mean you; "we" means the researchers and other staff.

Purpose
You are being asked to be in a research study of the effects of a device on metabolic rate changes after a low intensity physical activity. This device is named Desk Jockey (Desk Jockey LLC, Detroit, MI). This study is being conducted at Wayne State University (WSU). The estimated number of study participants to be enrolled at WSU is 40. Please read this form and ask any questions you may have before agreeing to be in the study.

Study Procedures
If you are eligible and agree to take part in this research study, you will be:

1) Asked to fast overnight for 5 consecutive days and come to the Exercise Physiology Lab located at the Eugene Applebaum School of Health Science and Pharmacy in the morning following each fast.
2) Measured for weight and height during the first visit only
3) Asked to sit down comfortably on an office chair next to an office desk.
4) Asked to put on a breathing mask and a nose clip. You will be asked to breathe through your mouth.
5) Asked to put your feet on the pedals of the device (Desk Jockey) which is placed under the desk.
5) Asked to sit without any foot movement for 10 min, followed by move your feet according to the speed of a metronome for 10 min. You will be instructed to pedal all the way to both ends of the pedal track.
6) Asked to remove your feet from the pedals and rest both feet on the ground for the remaining 40 min.
7) Asked to engage any sedentary activities you wish, such as reading, talking on the phone, surfing the internet, writing, etc.
8) Asked to have your mask and nose clip removed at the end of the 60 min period.
9) Receiving a snack and $50 as an incentive.

Benefits
There may be no direct benefit to you. However, information from this study may benefit other people now or in the future. The possible benefits to you for taking part in this research study are free estimate your resting energy expenditure.

Risks
By taking part in this study, you may experience the following risks: by moving your legs mimicking a walking condition, you may experience leg soreness. But this mild discomfortness will disappear shortly. There is also a potential of breach of confidentiality. In order to minimize this risk, the master list of participants' information will be kept in password-protected computers. Only the principal investigators have excess to these computers. After 3 year, this master list will be deleted permanently from the computers.

Study Costs
Participation in this study will be of no cost to you.

Compensation
For taking part in this research study, you will be paid for your time and inconvenience in the amount of $50.00 if you complete all 5 sessions, and $25 if you complete 3 sessions. If you do not complete the minimal 3 session requirement, you will not receive any compensation. We will also cover your parking expenses.

Research Related Injuries
In the event of this research related activity results in an injury, treatment will be made available including first aid, emergency treatment, and follow-up care as needed. Care for such will be billed in the ordinary manner to you or your insurance company. No reimbursement, compensation, or free medical care is offered by WSU. If you think that you have suffered a research related injury, contact the PI immediately at 313 -577-2500.

Confidentiality
All information collected about you during the course of this study will be kept confidential to the extent permitted by law. You will be identified in the research records by a code number. Information that identifies you personally will not be released without your written permission. However, the study sponsor, the Human Investigation Committee (HIC) at WSU, or federal agencies with appropriate regulatory oversight [e.g., Food and Drug Administration (FDA), Office for Human Research Protections (OHRP), Office of Civil Rights (OCR), etc] may review your records.

When the results of this research are published or discussed in conferences, no information will be included that would reveal your identity.

Voluntary Participation/Withdrawal
Taking part in this study is voluntary. You have the right to choose not to take part in this study. If you decide to take part in the study you can later change your mind and withdraw from the study. You are free to only answer questions that you want to answer. You are free to withdraw from participating in this study at any time. Your decision will not change any present or future relationship with WSU or its affiliates, or other services you are entitled to receive.

Questions

If you have any questions about this study now or in the future, you may contact Dr. Cathy Jen at 313-577-2500. If you have questions or concerns about your rights as a research participant, the Chair of the Human Investigation Committee can be contacted at 313-577-1628. If you are unable to contact the research staff, or if you want to talk to someone other than the research staff, you may also call 313-577-1628 to ask questions or voice concerns or complaints.

Consent to Participate in a Research Study

To voluntarily agree to take part in this study, you must sign on the line below. If you choose to take part in this study you may withdraw at any time. You are not giving up any of your legal rights by signing this form. Your signature below indicates that you have read, or had read to you, this entire consent form, including the risks and benefits, and have had all of your questions answered. You will be given a copy of this consent form.

______________________________________ __________
Signature of participant Date

______________________________________ __________
Printed name of participant Time

______________________________________ __________
Signature of person obtaining consent Date

______________________________________ __________
Printed name of person obtaining consent Time

APPROVAL PERIOD

MAR 14 '13 MAR 13 '14

WAYNE STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD

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ABSTRACT

Desk Jockey: A Device to Increase Non-exercise Activity Thermogenesis (NEAT) in Adults

by

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May 2014

Advisor: Dr. K-L Catherine Jen

Major: Nutrition and Food Science

Degree: Master of Science

Increased sedentary behavior, just like reduced physical activity, has been shown to increase the risk of obesity and chronic diseases. This is mostly due to increased time spent sitting at the office desk. There is limited research studying how to decrease such risk in office workers (OW). This study was to investigate a portable device "Desk Jockey" (DJ) on increasing NEAT and reducing sedentary behavior in a simulated office environment. Participants whose daily work requiring long sitting hours were recruited (mean sitting hours/day: 8.6 ± 3 hr, mean age: 25 ± 7 yr, 54% male, 15% obese). Metabolic rates (METs), energy expenditure (EE) and heart rates (HRs) were collected during five sessions, including one sedentary, with different paddling frequencies and resistances. Each session includes 10min rest, 20min paddling and 20min recovery. The results showed that paddling frequency is more important in METs than resistance ($p<0.01$). With the increase of BMI, EE increased significantly ($r=0.77$, $p<0.05$) regardless of different frequencies or resistances. METs increased significantly during paddling

in each session (0.90, 0.93, 1.26, 1.48, p's <0.01) compared to the sedentary session, while the METs were still very low (2.5 ± 0.6). Moreover, the METs and HRs during the first 10min recovery period were still significantly higher than those at resting state (p's<0.05). Therefore, DJ can be used by OWs to increase METs and EE not only during paddling, but also in 10min after cessation of paddling. Thus this device may be adapted for OWs to increase NEAT.

AUTOBIOGRAPHICAL STATEMENT

Jiangqi Tang graduated from Shanghai Normal University and received a Bachelor degree of Food Science and Engineering in 2012. She won the Third Academic Scholarship in her department for three years. The topic of her thesis was Analysis of Major Nutrients in Whole Wheat Flour. After graduation, she joined Wayne State University (WSU) to pursue a Master of Science degree in Nutrition and Food Science.

During her graduate studies, Jiangqi Tang worked as a student assistant in the "FIT Families Project" at WSU from 2012 till 2013. She was also a member of the Institute of Food Technologists from 2014 as well as the Nutrition and Food Science Club (IFTSA) of WSU.

Jiangqi Tang was a co-author of the poster at the Experimental Biology conference to be held in San Diego, CA in 2014. The title of this poster is: Desk Jockey: A Device to Increase Non-exercise Activity Thermogenesis (NEAT) in Adults. She was also a co-author of another poster: The Relationship of Serum 1,25OH2 Vitamin D Levels with Dietary Vitamin D Intake in Obese Minority Adolescents.