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THE EFFECTS OF A SHORT TERM HIGH-INTENSITY CIRCUIT TRAINING EXERCISE IN UNIVERSITY STUDENTS

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ABSTRACT

Background: Physical inactivity is one non-communicable disease threatening to become the fourth leading risk factor for global mortality. Japan is no exception especially in the younger population. The purpose of the study is to investigate the effect of high-intensity circuit exercise training (HICET) in university students. The second purpose is to examine the factors influencing exercise adherence.

Methods: This study was a home based experimental study with 65 healthy participants from the Osaka Kawasaki Rehabilitation University, Japan. An independent variable was the 7-minute HICET and a dependent variable was the physical fitness test (PFT) results. All participants were instructed to perform once daily a cycle of HICET, 2-3 times a week non-consecutively for 8 weeks. Pre and post PFT scores for men and women were compared for the effectiveness of the program. A brief survey was conducted 8 weeks after the completion of the study.

Results: Both groups showed improvement in sit-up, push-up, and 5-minute run after the 8 week HICET. The changes between pre and post scores were significant in all but the 5-minute run for women. Discontinuation rate 8 weeks after the study was higher in women than in men, but not statistically significant with no dropouts during intervention.

Discussion: An 8 week home based HICET significantly improved strength for both genders and endurance for men of the university students when measured by PFT. The exercise barriers should be assessed and adapted to fit individual needs to improve adherence rate.

Keywords: HICET (High-intensity circuit exercise training), exercise, strength, endurance, university students, adherence

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INTRODUCTION

Physical inactivity, one non-communicable disease, is a widely recognized issue contributing to many health conditions, including cardiovascular and musculo-skeletal disease, overweight, type-2 diabetes, and mental health^{1,2} Physical inactivity is a major public health issue and a common problem in all ages from childhood to elderly.^{1,3} According to the report on the worldwide prevalence of physical inactivity by Dumith SC. et al.⁴, one out of five adults around the world is physically inactive. In general, women are more inactive than men and the prevalence of inactivity increased with age^{4,5,6}. Moreover, physical inactivity increased in developed countries compared to that in less developed countries⁴. The World Health Organization (WHO) reported the level of physical inactivity is rising in many countries, threatening to become as the fourth leading risk factor for global mortality¹.

According to the 2013 public opinion poll of 1897 individuals (men = 891, women = 1006, age range = 20 through over 70 years) in regard to the status of individuals' physical activity conducted by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) in Japan⁷, the majority of people who felt they were healthy (87%) did not change from the last survey in 2009. However, the percentage of people who felt a decrease in physical endurance was 38.1% which was a slightly increased from 37.4% in 2009. There was a tendency for women to have less confidence about their physical endurance (43.1%) when compared to that of men (31.9%)⁷. When looking at the age-specific rate, a group of 20 through 29 year olds felt a decrease in endurance level at 32%. This was almost the same as that seen in a young senior group of 60 to 69 years at 32.9%. The majority of people (75%) felt they were not doing enough exercises. When compared between sexes, women felt less active than men at 77.9% and 71.0% respectively. In addition, young people (20 to 29 years) had a higher percentage of acknowledging the lack of exercises at 82.3%, compared to that of young seniors (60 to 69 years) at 62.2%. In Japan it was found that the younger individuals felt they had lower endurance and decreased exercise in comparison to those in young senior individuals.⁷

One way to measure physical activity level is using a pedometer in which the number of steps a day is counted and referenced as a measure of daily activity. In a public health promotion, the Ministry of Health, Labor and Welfare in Japan recommends taking 10,000 steps a day for adults to burn 300 calories, based on a required 2000 kcal energy expenditure a week⁸. This simple 10,000

steps a day activity became widely recognized as a measurement of recommended daily regular activity in Japanese society. In 1997 the Japanese National survey of Health and Nutrition reported that the average number of steps a day per individual was 8,202 for an adult man and 7,282 for an adult woman⁸ which had decreased to 7,099 a day and 6,249 a day in 2014 respectively.⁹

These were amazing facts when looking at a comparison of the number of steps a day in school aged individuals. The Tokyo Metropolitan Board of Education implemented a study of 16,100 students in elementary schools (n=9858), junior high schools (n=5120), and high schools (n=1122), called "2011 Daily Activity Level in School Children and Students in Tokyo"¹⁰. In the study each student wore a pedometer during weekdays and a total number of steps were counted. The result showed that boys had greater number of steps a day as compared to girls. These findings were similar to that of the public opinion polls mentioned earlier.⁷ The specific results were as follows; the average number of steps a day for boys in elementary schools was 13,300-14,000 and 10,000 for girls. The average number of steps a day for boys in junior high schools was 9,400 for boys and 8,350 for girls. The average number of steps a day of students in high schools was 9,000 for boys and girls. The total number of steps a day decreased as the grade of school year increased with the exception of high school students. A possible reason of this exception was that many high school students used public transportations to get their schools located outside their residences requiring a long distance walk to get the nearest stations.¹⁰

Tominaga et al.¹¹ found that increased inactivity had effected a decrease in strength of anti-gravity muscles, back muscles, in university students. They also found that many students did not exercise on a regular basis. Men had better scores in physical and psychological status as well as exercise habit compared to those in women. They concluded that there was a strong relationship between physical strength and life style (eating and sleeping habit) and suggested that having regular exercise would improve their life style.

Many individuals find that starting a regular exercise is challenging but maintaining it is more burdensome. Dishman¹² reported a dropout rate of adults at 50% within the first 6 months of starting an exercise program. The most common barrier to physical activity was lack of time.¹² Other issues associated with exercise adherence is the lack of proper instruction of the planned program resulting in poor exercise technique, leading to higher perceived exertion and greater difficulty in

completing the exercise program.¹³ Self-consciousness about one's appearance in the exercise facility and the planned exercise which individual found very vigorous were also the reasons for exercise in-adherence.¹³ The author mentioned that those individuals who had difficulty in continuing their exercise program in a public place might have continued the program in a private setting.¹³ In fact, Bravo¹⁴ found that a home-based exercise program had a greater adherence rate when compared to that of group-based exercise program.

Regardless of ages it appears that the majority of people lack a regular exercise program. Further, those who started an exercise program have great difficulty in continuing it on a regular basis. Despite the numerous physical and psychological scientific evidence and benefits of exercises that have been reported for years¹⁵, the above mentioned data clearly showed decline in the status of physical activity in all ages in Japan and did not support that we acknowledge the benefits of exercises. The findings reported by Tominaga et al.¹¹ showed that improved physical strength correlated to exercise habit and mental status of the university students. It is, therefore, hypothesized that providing a regular exercise program in the school setting might facilitate students to have an exercise habit with an increase in their physical fitness level. Moreover, it is speculated that the majority of young people have not experienced positive effects from a regular exercise program. It is, therefore, necessary to provide them a firm opportunity to experience a structured exercise program. The purpose of this study is to investigate the effects of a short term high-intensity circuit exercise training (HICET) on strength and endurance in the university students. The second purpose is to examine the factors influencing exercise adherence.

METHODS

Participants

Sixty-five non-disabled physical therapy students (men=51, women=14, age range from 19 to 21 years, mean age of 19.6 years) who registered in the Therapeutic Exercise class at the Osaka Kawasaki Rehabilitation University participated in this study. However, 2 men and 2 women were not able to obtain post data due to personal reasons, therefore, the total number of students was 61 used for the statistical analysis. This study was conducted during the fall semester in 2014 as part of the therapeutic exercise class taught by a registered senior physical therapist for the second year physical therapy students. All participants denied any recent history of musculoskeletal and

neurological pathology of the upper/lower extremities and low back, and signed an institutional approved consent form that informed them of the nature of study and their right as the participants.

Procedure

In the study, the 7-minute High-intensity Circuit Exercise Training (HICET)¹⁶ was chosen as an independent variable and the physical fitness test¹⁷ results as a dependent variable. The high intensity circuit exercise training (HICET) introduced by Klika and Jordan¹⁶ was chosen as a home based exercise program for the participants. The HICET consists of a series of exercises in 12 stations; 1) jumping jacks, 2) wall sit, 3) push ups, 4) abdominal crunch, 5) step-up onto chair, 6) squat, 7) triceps dip on chair, 8) plank, 9) running in place with high knee, 10) lunge, push-up and rotation, 11) side plank right, and 12) side plank left. These exercises were performed in this order to alternate the exercising muscle, and each station lasted for 30 seconds with a 10-second rest time between stations.

In the class the participants were given pictured exercise instruction and were in groups of 6 with the senior physical therapy students as their group instructors. Instructors, previously trained by the senior physical therapist for all individual exercises of HICET and trained in how to modify them according to individual needs, were assigned each group. In the first day of class, under supervision of the senior physical therapist, participants were given an individualized lesson for each exercise and the instructors modified the exercise as necessary to adapt to his or her level of physical needs.

Modifications were needed for the participants especially for the participants who were not able to perform some exercise items in a standard position for 30 seconds. All participants were encouraged to use media devices to access the internet site for this exercise program to keep up with the order of the HICET, the length of each station, and the recommended resting time. This intervention was an independent home practice. All participants were instructed to perform a cycle of HICET one time a day, 2-3 times a week non-consecutively for 8 weeks at a convenient time. The intensity was set as medium to high, rated 6-8/10 on a visual analog scale (VAS) where 0 is no intensity and 10 is maximal intensity. They were also instructed in keeping an active log that included the frequency of HICET.

Physical fitness test (PFT)

The Japan Athletic Associate (JAA) provides the PFT¹⁷ that is standardized in age-based norm ranged 4 to 65 years for both sexes. The number of repetitions that a participant performed for each test item was converted into 1 through 10 points. The test items were sit-up, push-up, and 5-minute run. Adapted protocol of each test item was provided at the JAA internet home page¹⁷. The change in the points before and after the intervention were compared for the effectiveness of the HICET.

A brief survey was also conducted 8 weeks after the completion of the intervention to learn about the frequency of the HICET, any functional change in which the participants felt in their activities of daily life during and after intervention, and the factors influencing exercise adherence. This study was approved by an ethic committee at the Osaka Kawasaki Rehabilitation University.

Data analysis

Statistical analysis was performed using the R Project for Statistical Computing software version 3.1.0. The significance of any differences before and after training was determined either by Student's t-test (for paired or unpaired data), or by the non-parametric Welch two sample t-test and where appropriate with the F test. An alpha level of .05 was used as the criterion for significance of difference.

RESULTS

Due to personal reasons, 4 out of 65 participants could not fully complete the study. In the raw scores, men outperformed women. While men showed significant increases over the 8 week HICET in mean scores of all three variables; sit-up (25.9 ± 5.7 , 29.3 ± 4.8 , $p < 0.001$), push-up (18.6 ± 9.0 , 23.8 ± 8.6 , $p < 0.001$) and 5-min run (932.4 ± 130.0 , 981.8 ± 104.2 , $p < 0.001$), women showed the significant improvements in mean scores of sit-up (16.7 ± 5.4 , 18.8 ± 3.9 , $p < 0.037$) and push-up (11.5 ± 5.6 , 20.4 ± 7.7 , $p < 0.0013$), but not in 5-min run (932.4 ± 130.0 , 981.8 ± 104.2 , $p < 0.001$). (Graph1-A, 1-B, 1-C). In the standardized score, there were no significant differences between men and women at the moment of pre-intervention. The difference between men and women in the standardized sit-up score approached statistical significance (8.12 ± 1.94 , 6.91 ± 2.15 , $p = 0.0641$). Men showed significantly better scores than women in the standardized 5-min run score (1.33 ± 1.23 , 0.41 ± 1.00 , $p = 0.021$). (Graph2-A, 2-B, 2-C). Discontinuation rate was higher in women

than men (83% and 67%, respectively), but not statistically significant (X-squared = 1.18, $p = 0.28$).

Post survey

A brief post survey was conducted 8 weeks after the completion of the study. The survey questions included frequency of HICET during intervention, current status in continuity of HICET, a question about reasons of discontinued HICET or negative aspects of HICET, and any functional change noted during and/or after the intervention.

The number of days a week the participants performed HICET ranged from 2 to 4 times a week with the average of 2.95 days. The majority of participants (80%) performed HICET 3 times a week, 13% performed twice a week, and 7% performed 4 times a week.

Eighteen out of 61 participants (men=16, women=2) or approximately 30% had continued HICET. Discontinuation rate was higher in women than that of men being 83%, 67% respectively.

Of forty-three participants or approximately 70% who discontinued HICET after the intervention period, four participants were doing own exercise program instead of HICET, two participants continued a selected part of HICET, and 11 participants continued their recreational sports once a week as usual and the rest (20 participants) were not doing any kind of exercises after completion of the study. Fifty-seven participants experiencing muscle soreness range from minimal to severe of which 10 participants experienced moderate to severe muscle soreness.

The reasons for discontinuing HICET included 22 participants felt that there was no time for HICET due to busy school work, and 6 participants felt vigorousness of HICET that negatively affected to continue HICET. Two participants mentioned continued minimal muscle soreness as an excuse. Two participants noted lack of motivation for HICET due to no purpose of doing it after the semester was over. Similarly, one participant mentioned that he completely forgot about it after the semester was over (no more homework).

The following functional changes during and after intervention were listed in the survey. Four participants felt it was easier going upstairs of the school building. Two participants felt it was easier riding a bicycle on an upslope and standing in a train/bus during transportation. One participant felt it was easier to lift heavy boxes with his part time job and a decrease in fatigue at the end of school.

DISCUSSION

Performing a 7-minute HICET 2-4 times a week non-consecutively for 8 weeks significantly improved the post mean scores of sit-up and push-up for both genders and the post mean score of 5-minute run for male. This result clearly supported the benefit of HICET.

Circuit training, consecutively arranged series of exercises, was developed by Morgan RE and Anderson GT in 1953¹⁸. In this training, a participant moves from one station to the next with little rest (15-30 seconds) or no rest depending on the purpose or physical level of the participant, performing 15 to 45 second workout with a resistance of 40-60% of IRM¹⁸. To get aerobic benefit a 30 second to 3-minute aerobic station is added¹⁸.

In general, resistance exercise training and endurance exercise training were performed separately. The reasons for choosing this HICET instead of a traditional exercise training are as follows: 1) HICET has both benefits of promoting strength and endurance, using a large group of muscles to create the appropriate resistance and aerobic intensity, 2) the participants could use of major muscles throughout the body (upper/lower extremities and core), 3) the exercise menus were relatively simple and familiar to the participants and appropriate for them to perform in their home space in a relatively safe manner, 4) all menus were easy to adapt and modify for individual physical needs, 5) the participants had no expense for special equipment but a chair and wall, and 6) the participants only required approximately 7 minutes for completion of a cycle of the HICET.

In the study, all menus of HICET for strengthening and endurance were distributed throughout 12 stations covering whole bodywork. Of the 12 stations of HICET, three stations, (1) jumping jacks, (5) step-up onto chair, and (9) high knees running in place, are considered as aerobic menus. Three stations, (3) push-up, (7) triceps dip on chair, (11) push-up and rotation, are strengthening stations for upper extremity muscle group. Three stations, (2) wall sit, (6) squat and (10) lunges are strengthening stations for lower extremity muscle group, and remaining three stations, (4) abdominal crunch, (8) plank, and (12) side plank right/left are focused on core strengthening. The recommended order of these stations are also important to alternate exercising muscles that helps to recover the muscle group just worked in the previous station while working on other muscle group in subsequent station.

A standard rest time between stations in circuit training ranging from 15 to 30 seconds is suggested¹⁸. Klika and Jordan, however, recommended, a 10-second rest, less than standard minimal rest time, in order to maximize the benefit of this high intensity training protocol and for maximizing time efficacy. This 10-second rest time appeared to be too short for some participants. It seemed not enough for them to prepare for the next exercise so that the beginning of the exercise was not probably performed in a proper manner. This would cause increased effort to continue the exercise program. To determine the proper level of intensity the amount of rest time is as important as menu itself.

Use of body weight as resistance seemed to work well in terms of convenience, inexpensiveness, and portability. This super advantageous body weight resistance, on the other hand, might have a limitation. For example, sedentary participants might have difficulty in maintaining moderate resistance using body weight throughout all menus. Although the change of body position could alter (lower) the body weight taken by the exercising muscle group, it may not be enough to lower the intensity. It was speculated that use of body weight as resistance easily exceeded the recommended intensity. This might be contributing to the result of 5-minute run for women whose post score did not improve as much as that of strength. To improve muscle endurance the exercise requires moderate intensity with an increase in repetitions.

Although this HICET had multiple benefits, only 18 participants or 30% continued HICET after completion of the study. When looking at the discontinuation rate between genders, women had higher discontinuing rate at 83% compared with that of men that was 67%. This result showed that women had difficulty in continuing the exercise program, reminding that a higher inactive rate was found in women worldwide⁴ Approximately one-third of participants mentioned the lack of time or time constrained issue as a reason for discontinuing the program although one cycle of HICET only lasted approximately 7 minutes. However, for some participants, the nature of this program may not be comfortably fitted into their after school activities. After spending over 8 hours in school, it would be difficult for some participants to be motivated to do a series of intense exercises. Their priority is to manage their physical energy to prevent fatigue and sustain engagement in all classes throughout a day.

This leads to another reason of discontinuing the program mentioned by 6 participants that it was too vigorous. At the beginning, the intensity of

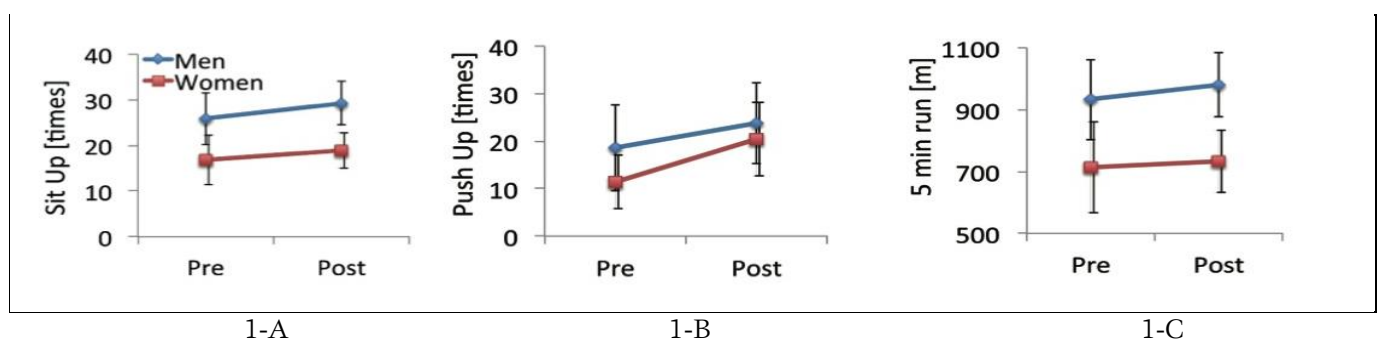
HICET was set at 6 to 8 out of 10 discomfort level to maximize the exercise benefits. This might have strongly contributed to their discontinuation. For some individuals setting the intensity level should not be at discomfort level but the level at which an individual can perform without great effort. Borg²⁰ stated that the degree of discomfort is directly correlated to an individual's body weight, current fitness level, and one's sedentary lifestyle. This indicates that individuals with higher sedentariness would have higher discomfort level compared to that of individuals with less sedentariness while performing the same exercise program. Therefore, the intensity should not be set as a "one fit for all" concept. They may require starting out with some gentle stretches as warm-up and finishing with again gentle stretches as cool down as well as a longer rest time between menus that may help with preparation and delay onset of muscle soreness.

In the beginning of this study, all participants were instructed in how to decrease or increase the intensity of each exercise to allow individual control. Apparently, this part was not thoroughly understood by some participants, as this was only one-way instruction without periodical feedbacks from them. It would be assumed that those who could not understand proper adjustment for the exercise intensity would have performed the exercise in an improper position in an overly strenuous manner.

Muscle soreness as a negative factor especially for women was also a reason of discontinuation. Two female participants mentioned minor muscle soreness that caused discontinuation of the program. Interestingly, those who were male and experienced moderate to severe muscle soreness did not mention muscle soreness as a discontinuation reason.

No participants dropped out of the exercise program during intervention, probably due to the study design of performing home based HICET as part of the course study. In fact, one participant discontinued the program because he simply forgot about it as soon as the semester was over. He might

Graphs:



have remembered if this program was continued and mentioned as a part of his lifetime homework.

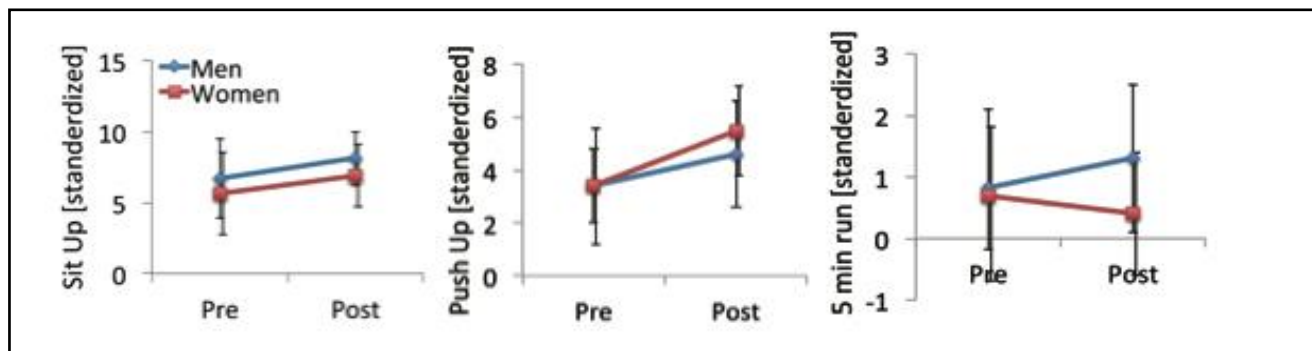
Appropriateness of this program for all participants as a regular exercise program was questionable. Exercise programs should be based on individual needs and preference regardless of individual physical status. The exercise program should have set goals for each individual and should be monitored by exercisers and instructors. This would add to the program some fun and rewards. This part was lacking in the current study and should be included in a future study.

A true change in the status of strength and/or endurance should be detected in function. Multiple positive functional changes during and after the program were reported. Outcome measurements for the exercise effectiveness should be school related functional changes that support and improve academic and clinical performances such as degree of alertness during class, sitting endurance, proper posture in sitting and standing, and ease of accessing the school building. Adding modification to this program for some participants with an increase in resting time, adding warm-up and cool-down menus, giving thorough instruction on how to modify intensity would help to adapt the program to the individual needs that in turn would improve adherence rate to the program. Most importantly, without a doubt, these young individuals need to be convinced of the importance of physical activity for health. Providing a structured exercise program in part of the school might facilitate to take a responsibility for their active life.

SUMMARY

An 8-week HICET improved strength for both genders and endurance for male of the university students when measured by PFT. The nature of HICET might be partly responsible for discontinuance of this program. The program should be enjoyable, rewardable, and goal oriented. The exercise barrier should be assessed and adapted to fit individual needs that would improve adherence rate.

Graph 1: 1-A, 1-B, and 1-C show pre and post row mean scores of men and women for sit up, push up and 5-minute run respectively.



2-A

2-B

2-C

Graph 2: 2-A, 2-B, and 2-C show pre and post row mean scores of men and women for sit up, push up and 5-minute run respectively.

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