

UNIVERSITY OF WISCONSIN-LA CROSSE

Graduate Studies

MINI-TRAMPOLINES: DO THEY PROVIDE A SUFFICIENT AEROBIC
WORKOUT?

A Manuscript Style Thesis Submitted in Partial Fulfillment of the Requirements for the
Degree of Master of Science in Clinical Exercise Physiology

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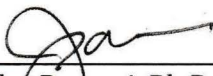
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MINI-TRAMPOLINES: DO THEY PROVIDE A SUFFICIENT AEROBIC WORKOUT?

By Paige Burandt


We recommend acceptance of this thesis in partial fulfillment of the candidate's requirements for the degree of Master of Science in Clinical Exercise Physiology

The candidate has completed the oral defense of the thesis.



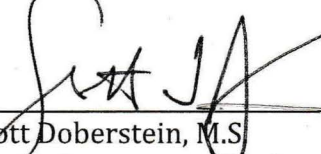
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ABSTRACT

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Purpose: To determine if a mini-trampoline exercise routine from JumpSport met guidelines set by ACSM for improving cardiorespiratory endurance **Methods:** Twelve male (age 20.8 ± 2.09 years) and twelve female (age 20.7 ± 1.30 years) subjects performed a graded exercise test on a treadmill. Then subjects performed the selected 19 minute exercise routine on a mini-trampoline. Physiological responses, HR and VO_2 were monitored throughout. Perceived exertion was recorded every 5 minutes throughout the workout and at the end using the Borg 6-20 RPE scale. **Results:** It was found that both %HRmax (males: 77 ± 6.3 ; females: 80 ± 7.3) and % VO_2 max (males: 58 ± 8.4 ; females: 61 ± 6.7) met the guidelines of 64-94% of HRmax and 40-85% of VO_2 max set by ACSM. Throughout the workout subjects considered it to be of “light” intensity when using the 6-20 Borg RPE scale (males: 11.5 ± 2.0 ; females: 11.6 ± 1.24). Caloric expenditure for both males (12.4 ± 1.60 kcal/min) and females (9.4 ± 0.9 kcal/min) also met guidelines for weight loss. Males had a significantly higher energy expenditure than females due to higher body mass (184.0 ± 30.70 lb vs. 142.0 ± 13.06 lb). **Conclusion:** The selected JumpSport routine does meet the standards set forth by ACSM to improve cardiorespiratory fitness and to stimulate weight loss.

ACKNOWLEDGEMENTS

To my parents, for instilling in me, from a very young age, the virtues of hard work, continuous education and caring for others. To my brother for his quiet, yet constant support from afar. To my best friends for their never-ending love and encouragement when I needed it the most. To my research assistant for keeping me grounded during all the crazy moments, and making me laugh during the tough ones. And lastly to my friends and family members who continued to believe in me, even when others no longer did.

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INTRODUCTION

Trampolines have been a popular form of recreation in the United States for over 50 years. They first emerged in 1936 as a recreational activity and sport, but have found a much wider range of uses. In WWII they were used in the training of fighter pilots (Esposito & Esposito, 2009). Trampolines supposedly helped increase spatial awareness and balance abilities of pilots. After the war, their popularity soared with many gyms and schools sponsoring competitive teams. Once their international popularity increased, trampoline competition was introduced as an Olympic event (Esposito & Esposito, 2009).

Over the years a number of studies have been performed on the effectiveness of mini-trampolines as an exercise modality. In 1978, NASA concluded that trampoline training was as effective at aerobic training as running (Bhattacharya, McCutcheon, Shvartz, and Greenleaf, 1978). The researchers examined the relationship between heart rate (HR) and oxygen consumption (VO_2) during running on a treadmill and jumping on a mini-trampoline. It was found that both modalities maintained a similar linear relationship between HR and VO_2 . Additionally, there was no significant difference in submaximal VO_2 between the two exercises, leading to the conclusion that the energy requirements of jumping and running are similar. McGlone, Kravitz, and Janot (2002) also reinforced the effectiveness of jumping on a trampoline in comparison to running. Their study found no significant differences in maximal HR, VO_{2max} or energy expenditure (kcal) when exercising on a mini-trampoline in comparison to running on a treadmill.

Conversely, Gerberich et al. (1990) had subjects perform incremental maximal exercise tests on a treadmill and a mini-trampoline. Subjects achieved higher VO_2max values jogging on the treadmill compared to bouncing on the mini-trampoline. Edin et al. (1990) conducted an 11-week training study using a mini-trampoline. They found no significant differences in body weight, percent body fat, and lipid levels between the training group and the control group after the training program. Although the training group did achieve a 4.4% improvement in their VO_2max , it was not statistically significant.

Although many studies have looked at the effects of exercising on a mini-trampoline, there is little data supporting its efficacy as a tool to increase cardiorespiratory endurance and positively affect body composition. The American College of Sports Medicine (ACSM) recommends exercising at 64-94% of HR_{max} or 40-85% of VO_2max 5 days/week for 30-60 min/day (ACSM, 2014). Although ACSM (2014) does not have any caloric expenditure recommendations for the healthy adult, and earlier article about weight loss stated that to stimulate weight loss it is recommended that a person have a caloric deficit of 500-1000 calories/day with ~300 of those coming from physical activity (ACSM, 2011).

Recently, fitness centers have begun offering group exercise classes, which lead participants through a mini-trampoline based exercise routine. The purpose of this study is to determine the intensity of an individual mini-trampoline exercise routine and compare it to the established guidelines by ACSM for cardiorespiratory endurance and caloric expenditure.

METHODS

Subjects

Subjects for this study were 24 apparently healthy college students recruited from the UW-La Crosse campus. All subjects were recreationally active (exercising at least 3 times weekly for the past 6 months). Each subject completed a PAR-Q to screen for cardiovascular and orthopedic contraindications to exercise. Each subject provided informed consent prior to participating in this study. This study was reviewed and approved by the University of Wisconsin – La Crosse Institutional Review Board for the Protection of Human Subjects.

Procedures

Initially, each subject completed an incremental maximal exercise test on a treadmill. Subjects walked on a motorized treadmill at a self-selected pace, which stayed constant throughout the test. The incline began at 0% grade and increased by 2.5% every two minutes and continued until volitional exhaustion. During this test, HR was monitored continuously using a Polar heart rate monitor (Polar Electro, Kempele, Finland) and VO_2 was continuously monitored using an AEI metabolic cart (AEI Technologies, Pittsburgh, PA). At the end of each stage and at maximal exertion subjects rated their perceived exertion using the 6-20 Borg (RPE) Scale (Borg, 1998).

Following completion of the VO_2 max test, subjects practiced various movements and choreography used in the JumpSport video (JumpSport Inc. San Jose, CA), to familiarize themselves with the activity. Subjects were able to practice on the mini-

trampoline until they felt comfortable. Once deemed proficient by the principle investigator, subjects completed a monitored trampoline exercise session while following the routine designed by JumpSport. The video was played on a computer screen for the subjects to watch and they were instructed to follow along with the routine. The routine was 19 minutes in length and incorporated a variety of movements to utilize the whole body. All sessions took place in the Human Performance Laboratory (HPL) on the UW-La Crosse campus. Throughout the exercise session, HR and VO_2 were measured in the same manner as the treadmill test and values were recorded every minute. Caloric expenditure was calculated from the VO_2 data assuming a constant of 5 kcal/liter of oxygen consumed. Rating of perceived exertion was assessed every 5 minutes during the workout using the 6-20 Borg scale.

RESULTS

The descriptive characteristics of this subject population are displayed in Table 1.

Table 1. Descriptive characteristics of subjects.

	Males (n=12)	Females (n=12)
Age (years)	20.8 \pm 2.09	20.7 \pm 1.30
Height (in)	69.9 \pm 2.76	65.6 \pm 2.05
Weight (lbs)	184.0 \pm 30.70	142.0 \pm 13.06
HRmax (bpm)	182 \pm 11.5	185 \pm 7.1
VO ₂ max (mL/kg/min)	52.6 \pm 8.53	48.2 \pm 5.63

The responses to the workout portion of the JumpSport routine are presented in Table 2 and Figures 1-4. The workout portion was defined as the middle 13 minutes. This excluded the first 3 minutes and the last 3 minutes, which were the warm-up and cool-down periods respectively. It was found that absolute HR, %HRmax, relative VO₂ and %VO₂max were similar for both genders. Males burned significantly more calories than the females, due to their higher body mass.

Table 2. Average responses during the JumpSport workout, excluding the warm-up and cool-down.

	Males	Females	Overall
HR (bpm)	141 ± 14.9	149 ± 14.1	145 ± 14.8
%HRmax	77 ± 6.3	80 ± 7.3	79 ± 6.9
VO ₂ (ml/kg/min)	29.7 ± 1.69	29.1 ± 2.33	29.4 ± 2.01
%VO ₂ max	58 ± 8.4	61 ± 6.7	59 ± 7.6
Kcal/min	12.4 ± 1.60*	9.4 ± 0.90	10.9 ± 1.99
RPE	11.8 ± 1.05	11.6 ± 1.65	11.7 ± 1.36

Values represent mean ± standard deviation

*significantly different than females (p < .05).

The average HR responses for each minute of the mini-trampoline routine are presented in Figure 1.

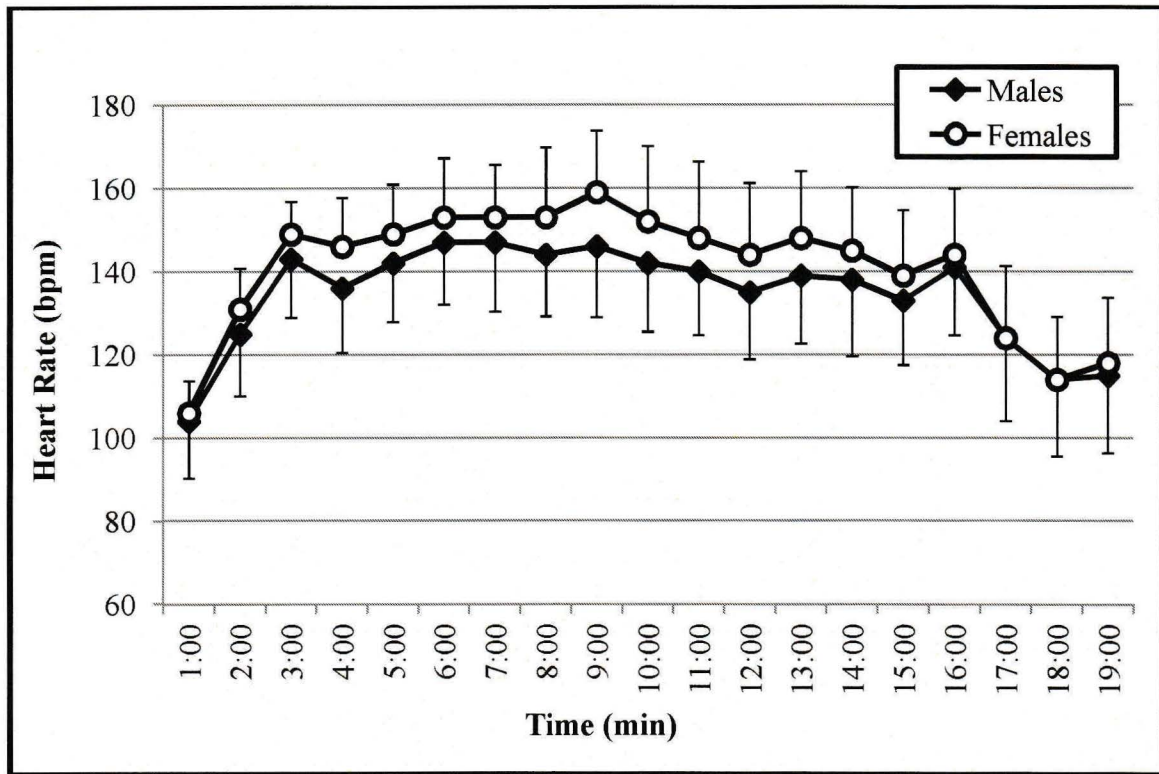


Figure 1. Heart rate responses of males and females over the course of the workout.

Relative HR responses (%HRmax) of subjects during each minute of the mini-trampoline are presented in Figure 2. The boxed region indicates the current ACSM guidelines for improving cardiorespiratory fitness (64%-94% of HRmax).

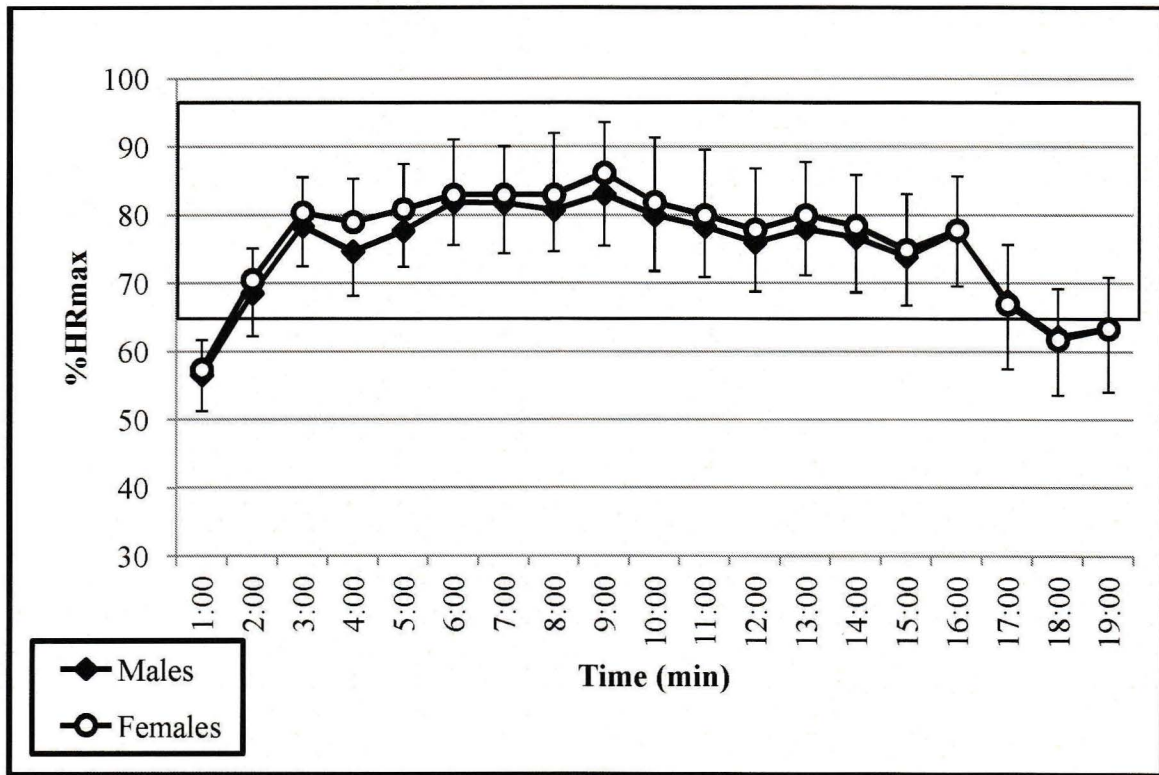


Figure 2. %HRmax of males and females over the course of the workout.

The average VO_2 responses for each minute of the mini-trampoline routine are presented in Figure 3.

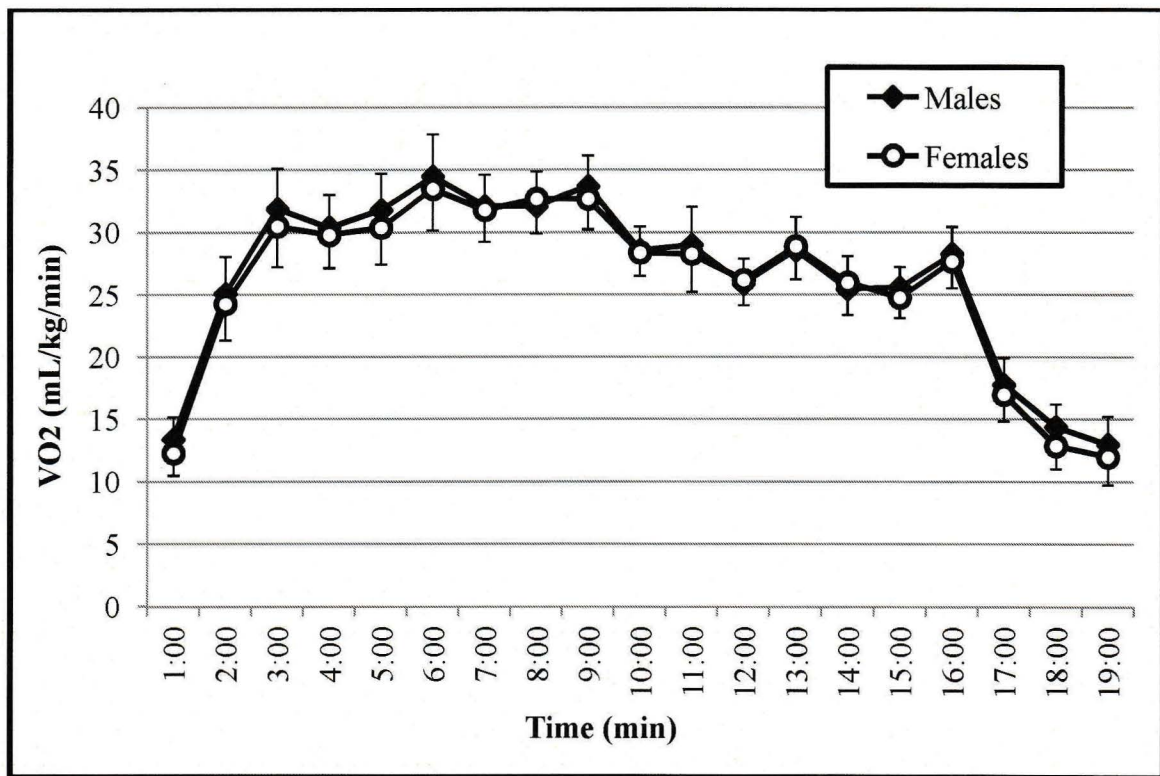


Figure 3. VO_2 responses of males and females over the course of the workout.

Relative oxygen consumption responses ($\%VO_2\text{max}$) of subjects during each minute of the mini-trampoline are presented in Figure 4. The boxed region indicates the current ACSM guidelines for improving cardiorespiratory fitness (40%-85% of $VO_2\text{max}$).

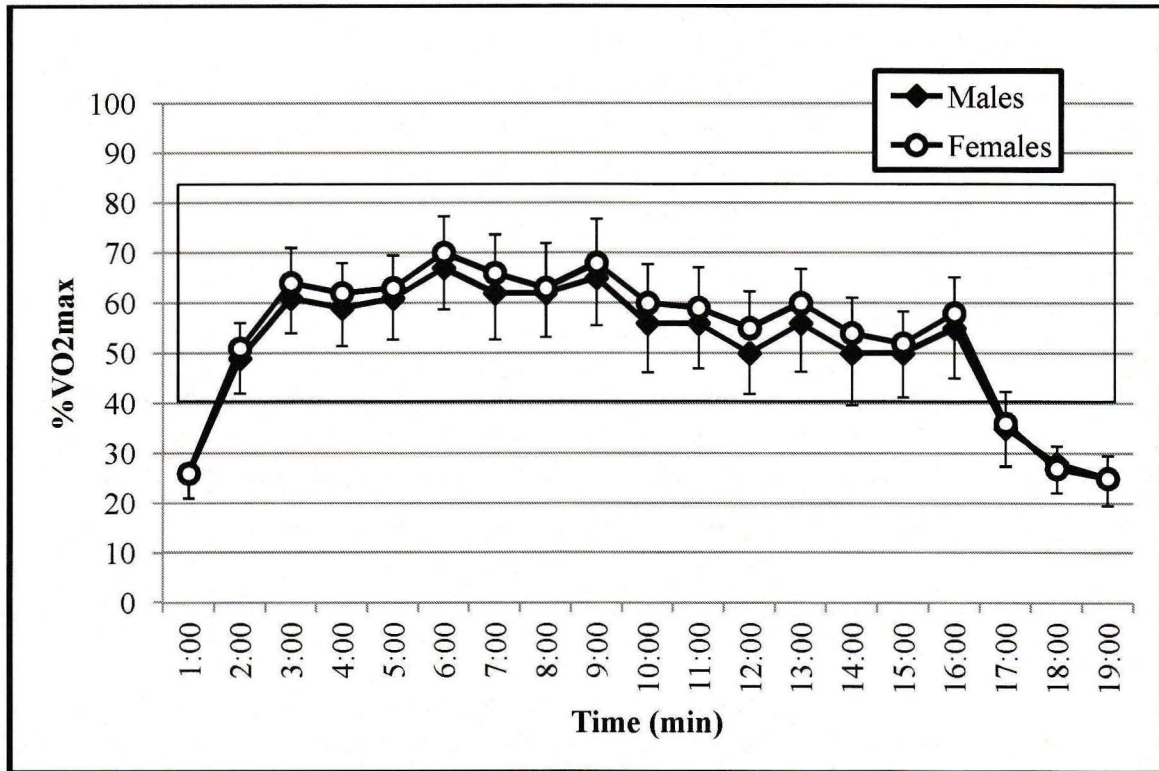


Figure 4. $\%VO_2\text{max}$ of males and females over the course of the workout.

DISCUSSION

The purpose of this study was to determine if the mini-trampoline routine from JumpSport met the guidelines set forth by ACSM for improving cardiorespiratory fitness. American College of Sports Medicine (2014) currently recommends exercising at 64-94% of HRmax and 40-85% of %VO₂max to achieve these benefits. It was found that this routine does meet the recommendations as during the workout portion of sessions average HR was 79% of HRmax and average VO₂ was 59% of max. The only times spent outside the recommendations were during the warm-up and cool-down phases of the workout. In a previous study, Edin et al. (1990) found that subjects who completed an 8-week training program exercising on a mini-trampoline kept their heart rate between 70-85% of HRmax and increased their VO₂max by 4.4%. In this study subjects kept their HR in a similar zone of 64-94% HRmax. Thus, the JumpSport routine should provide a similar cardiorespiratory benefit.

Another method of determining relative exercise intensity is through the use of RPE. During the workout portion of the DVD, males and females ranked the intensity of the exercise as 11.6 and 11.8 respectively. Based on the verbal anchor points of the Borg scale, this would classify the workout as “light” to “moderate”.

Caloric expenditure is usually at the forefront of everyone’s mind when evaluating new exercise modalities or regimens. American College of Sports Medicine (2011) currently recommends burning 200-300 kcal during each 30 minute exercise session to result in weight loss or weight management. This recommendation

corresponds to burning 6.7-10 kcal/min. During the workout portion of this routine, males and females burned an average of 12.4 kcal/min and 9.4 kcal/min, respectively. When including the warm-up and cool-down portions of the workout, males and females burned 11.0 kcal/min and 8.3 kcal/min, for the 19 minute workout. Males burned more calories than females because of their higher body mass (184.0 lbs vs. 142.0 lbs). Although Edin et. al. (1990) did not see any changes in body fat or blood lipids after an 8-week training program, this routine does produce a caloric deficit which should result in fat loss. This level of energy expenditure would be equivalent to running at a 6 mile per hour pace on flat ground or biking at 14 miles per hour. Other activities with equivalent intensities are basketball, football and ultimate Frisbee (Ainsworth, et al. 2000).

Future research may want to directly compare exercising on the mini-trampoline to other, more well-known, exercise modalities. This would be helpful so that exercisers can make informed decisions about its efficacy. The impact on one's joints could also be studied. Mini-trampoline exercise is attractive in that it is purported to be very low-impact, but no evidence supports this to date. Balance is another area that this device claims improve, but there is no evidence to support that claim. Researchers may also consider looking into the enjoyabilty of this exercise modality. Although the data from this study supports it as physiologically beneficial, a modality is more likely to be used if subjects enjoy it.

Additionally, this routine was quite easy for subjects to learn. The majority of subjects needed only 10-15 minutes of practicing to feel comfortable with the routine and with using the mini-trampoline itself. For this reason, we feel comfortable recommending

this modality to the general population even if they have not used a mini-trampoline previously.

In summary, we found that this mini-trampoline routine does meet ACSM standards for improving cardiorespiratory endurance. This mini trampoline routine elicited HR and VO_2 responses that were within ACSM (2014) guidelines. The caloric expenditure for both sexes was also above the minimal guidelines recommended by ACSM (2011) for weight loss or management. This would make mini-trampoline exercise another enjoyable option for exercisers.

REFERENCES

- Ainsworth, B.E., Haskell, W.L., Whitt, M.C. Irwin, M.L., Swartz, A.M., Strath, S.J., O'Brien, W.L., Basset, Jr. D.R., Schmitz, K.H., Emplaincourt, P.O., Jacobs, Jr. D.R., Leon, A.S. Compendium of Physical Activities: An Update of Activity Codes and MET Intensities. *Medicine & Science in Sports & Exercise*. 2000.
- American College of Sports Medicine. (2014). *Guidelines for Exercise Testing and Prescription*. 9th ed. Philadelphia: Wolters Kluwer/Lippincott Williams & Wilkins Health
- American College of Sports Medicine Position Stand. Appropriate Physical Activity Intervention Strategies for Weight Loss and Prevention of Weight Regain for Adults. *Medicine & Science in Sports & Exercise*. 2011.
- Bhattacharya, A., McCutcheon, E.P., Shvartz, E., Greenleaf, J.E. Body Acceleration Distribution and O₂ Uptake in Humans During Running and Jumping. *Journal of Applied Physiology*. 1978.
- Borg, G. (1998). Borg's Perceived Exertion and Pain Scales. Champaign, IL: Human Kinetics
- Edin, J.B., Gerberich, S.G., Leon, A.S., McNally, C., Serfass, R., Shaw, G., Moy, J., Casal, D. Analysis of the Training Effects of Minitrampoline Rebounding on Physical Fitness, Body Composition, and Blood Lipids. *Journal of Cardiopulmonary Rehabilitation*. 1990.
- Esposito, P.W. and Esposito, L.M. The Reemergence of the Trampoline as a Recreational Activity and Competitive Sport. *Current Sports Medicine Reports*. 2009.
- Gerberich, S.G., Leon, A.S., McNally, C., Serfass, R., Edin, J.B. Analysis of the Acute Physiologic Effects of Minitrampoline Rebounding Exercise. *Journal of Cardiopulmonary Rehabilitation*. 1990.
- McGlone, C., Kravitz, L., Janot, J.M. Rebounding: A Low-Impact Alternative. *ACSM's Health and Fitness Journal*. 2002.

APPENDIX A

INFORMED CONSENT FORM

Informed Consent

Protocol Title: Mini-Trampolines: Do They Provide a Sufficient Aerobic Workout?

Principle Investigator: Paige Burandt
Graduate Student
University of WI-La Crosse
(608) 293-3395

Emergency Contact: Paige Burandt
(608) 293-3395

Purpose and Procedure:

- The purpose of this study is to determine whether a mini-trampoline exercise routine meets American College of Sports Medicine guidelines for aerobic activity.
- The trampoline routine that has been chosen is approximately 30 minutes in length and is designed to be of moderate intensity.
- I will be asked to complete a graded, maximal exercise test on a treadmill. During this test I will be wearing a mask to analyze my expired air as well as a chest strap to measure heart rate. I will also be asked to rate my subjective exertion at the end of each stage using a Borg RPE Scale.
- I will be asked to complete 3-5 “practice” trials on the mini-trampoline to become familiar with the routine and movements.
- Once comfortable with the movements I will be asked to complete an incremental maximal test on a mini-trampoline.
- I will then complete a monitored trampoline exercise session. During this monitored session my heart rate, expired air, and perceived effort will be monitored using the same methods as during the maximal treadmill test.

Potential Risks:

- I may experience fatigue or leg soreness after completing the maximal treadmill test.
- Falls are an inherent risk of trampoline use, but can be reduced with proper instruction and practice.
- Other relatively minor injuries that can occur with trampoline use are: lacerations, contusions, fractures, sprains/strains of the lower extremities, concussions, and maxillofacial injuries.
- Individuals trained in CPR, Advanced Cardiac Life Support and First Aid will be in the laboratory during all phases of this study, and the test will be terminated if complications occur.

Rights and Confidentiality:

- My participation in this study is voluntary and I can withdraw from the study at any time for any reason without penalty.
- All information will be kept confidential through the use of number codes and password protected computer files. The data gained from my participation in this study will not be linked to any personally identifiable information.
- The results of this study may be published in scientific literature or presented at professional meetings using grouped data only.

Possible Benefits:

- I will experience a new method of exercise.
- I will gain knowledge about my current level of fitness.
- I will be able to further appreciate the research process.

Questions regarding study procedures may be directed to Paige Burandt (608-293-3395), the principal investigator, or the study advisor Dr. John Porcari, Department of Exercise and Sport Science, UW-La Crosse (608-785-8684).

Questions regarding the protection of human subjects may be addressed to the UW-La Crosse Institutional Review Board for the Protection of Human Subjects, (608-785-8124 or irb@uwlax.edu).

Participant: _____

Date: _____

Researcher: _____

Date: _____

APPENDIX B

PAR-Q FORM

PAR-Q & YOU

(A Questionnaire for People Aged 15 to 69)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

YES	NO	
<input type="checkbox"/>	<input type="checkbox"/>	1. Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?
<input type="checkbox"/>	<input type="checkbox"/>	2. Do you feel pain in your chest when you do physical activity?
<input type="checkbox"/>	<input type="checkbox"/>	3. In the past month, have you had chest pain when you were not doing physical activity?
<input type="checkbox"/>	<input type="checkbox"/>	4. Do you lose your balance because of dizziness or do you ever lose consciousness?
<input type="checkbox"/>	<input type="checkbox"/>	5. Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?
<input type="checkbox"/>	<input type="checkbox"/>	6. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?
<input type="checkbox"/>	<input type="checkbox"/>	7. Do you know of any other reason why you should not do physical activity?

If
you
answered

YES to one or more questions

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

- You may be able to do any activity you want — as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
- Find out which community programs are safe and helpful for you.

NO to all questions

If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:

- start becoming much more physically active — begin slowly and build up gradually. This is the safest and easiest way to go.
- take part in a fitness appraisal — this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively. It is also highly recommended that you have your blood pressure evaluated. If your reading is over 144/94, talk with your doctor before you start becoming much more physically active.

DELAY BECOMING MUCH MORE ACTIVE:

- If you are not feeling well because of a temporary illness such as a cold or a fever — wait until you feel better; or
- If you are or may be pregnant — talk to your doctor before you start becoming more active.

PLEASE NOTE: If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

Informed User of the PAR-Q: The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completing this questionnaire, consult your doctor prior to physical activity.

No changes permitted. You are encouraged to photocopy the PAR-Q but only if you use the entire form.

NOTE: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

"I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction."

NAME _____

SIGNATURE _____

DATE _____

SIGNATURE OF PARENT _____

OR GUARDIAN (for participants under the age of majority)

WITNESS _____

Note: This physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if your condition changes so that you would answer YES to any of the seven questions.



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APPENDIX C

DATA COLLECTION FORM

Name: _____ Sex: **M F** Subject #: _____

Age: _____ years Height: _____ in Weight: _____ lb

Treadmill:

Testing Session: _____ at _____

Speed (mph): _____

Time	Grade (%)	RPE	HR	VO ₂
0:00 – 2:00	0.0%			
2:00 – 4:00	2.5%			
4:00 – 6:00	5.0%			
6:00 – 8:00	7.5%			
8:00 – 10:00	10.0%			
10:00 – 12:00	12.5%			
12:00 – 14:00	15.0%			
16:00 – 18:00	17.5%			
18:00 – 20:00	20.0%			
20:00 – 22:00	22.5%			
22:00 – 24:00	25.0%			
24:00 – 26:00	27.5%			
26:00 – 28:00	30.0%			

Trampoline:

Testing Session: _____ at _____

RPE: 5:00 _____ 10:00 _____ 15:00 _____

20:00 _____ Final _____

Comments:

APPENDIX D

BORG RPE SCALE

Rating	Perceived Exertion
6	No exertion
7	Extremely light
8	
9	Very light
10	
11	Light
12	
13	Somewhat hard
14	
15	Hard
16	
17	Very hard
18	
19	Extremely hard
20	Maximal exertion

APPENDIX E

PICTURE OF JUMPSPORT MINI-TRAMPOLINE



APPENDIX F

REVIEW OF LITERATURE

REVIEW OF THE LITERATURE

Physiological Responses to Mini-Trampoline Exercise

Trampolines have been a popular form of recreation in the United States for nearly 80 years (Esposito & Esposito, 2009). The first mini-trampoline prototype was created in 1936, but a patented version was not available to the general public until 1975. This made its full-sized cousin the king of recreational activities for over 40 years. George Nissen patented his full-size trampoline in 1936 and promoted it as a recreational activity, but it has found a much wider range of uses. Beginning in WWII, trampolines were used in the training of fighter pilots. Trampolines supposedly helped increase spatial awareness and balance abilities of these soldiers. After the war, their popularity soared with many gyms and schools sponsoring competitive teams. Trampolines became so popular that the first national championship was held in 1948. The public's fascination with trampolines only continued to grow and many families began purchasing full-sized trampolines for private use (Esposito & Esposito, 2009).

However the mini-trampoline (also called a rebounder), didn't catch on with the public nearly as fast. In fact, it wasn't until 1977 when Albert E. Carter and his family of professional gymnasts toured the country performing their trampoline show that people began to take notice of mini-trampolines (Esposito & Esposito, 2009). Carter has been hailed as "the father of rebound exercise" partly because his show's popularity, but largely due to the pamphlet "The Miracles of Rebound Exercise" that he published in 1979. This pamphlet, along with several studies extolling the benefits of mini-

trampolines, including one produced by NASA in 1978, were huge factors in the increase in popularity of the mini-trampoline (Esposito & Esposito, 2009). During the “aerobic craze” of the mid-80’s mini-trampolines became a necessary accessory for fitness instructors and their participants. It is uncertain why the popularity of mini-trampolines in the fitness industry has faded, although there is speculation about the poor-quality of foreign made equipment that was saturating the market. Although mini-trampolines as an exercise modality had faded, its use for athletic competitions remained as high as ever. By 2000 their international popularity had reached its highest ever and trampoline competition was introduced as an Olympic event (Esposito & Esposito, 2009).

Recently mini-trampolines have seen their popularity increase again as an aerobic training method. There are many recent studies that provide some evidence that mini-trampolines are an effective exercise, but none have compared them to established standards for aerobic activity.

Although Carter’s pamphlet sparked national attention, the first scientific study on mini-trampoline training was commissioned by NASA in 1978 and has become the go-to article for those claiming the benefits of rebounding (Esposito & Esposito, 2009). This is because its main finding was that trampoline training was as effective, if not more so, for aerobic training than running. This study was intended to study the effects of different exercises on persons subjected to a weightless environment for an extended time. The researchers were attempting to determine the best exercise to avoid deconditioning while astronauts were in space. The researchers studied eight young males. They analyzed the acceleration speeds at the subjects’ heads, lower backs, and ankles as well as their heart rate (HR) and oxygen consumption (VO_2). They had subjects walk/run at four different

speeds on a treadmill while measuring acceleration, HR and VO_2 . One week later subjects jumped on a trampoline at four different heights while the same measurements were taken. Researchers found that at similar HR and VO_2 , jumping on a trampoline had a “greater biomechanical stimulus” than running on a treadmill. They also found that the impact on the lower body was lessened during trampoline training (Bhattacharya, McCutcheon, Shvartz, and Greenleaf, 1978).

A later study had similar findings. This study was more focused on the effects of a mini-trampoline on body fat loss, but also measured $\text{VO}_{2\text{max}}$ before and after their training program. The 60 overweight women who were subjects were randomly assigned to one of three exercise modalities: running, biking, or rebounding. Each group met 4 days/week for 10 weeks to perform 30 minutes of their assigned exercise. Post-testing results revealed that all three modalities resulted in lower body fat percentages as well as higher $\text{VO}_{2\text{max}}$ (White, 1980).

A more recent study by McGlone, Kravitz, and Janot (2002) compared effectiveness of trampolines in comparison to running. After monitoring the responses of 10 well-trained subjects, they found no significant differences in HR or VO_2 . During this study subjects followed a trampoline routine lead by a certified instructor and rated it on Borg’s (1998) Rating of Perceived Exertion (RPE) scale. Later, subjects ran on a treadmill at 3% grade and self-selected speed. Subjects were instructed to select a speed that matched the RPE rating they assigned to the trampoline routine. Although there were no substantial differences between the two modalities, it was found that rebounding met ACSM guidelines of that time (2000) for aerobic activity. One main advantage of trampoline training is that it is low-impact. With jogging there is a great deal of impact

on one's body, but trampolines are able to absorb the vast majority of this shock (McGlone et al. 2002).

Even with the support that rebounding has gained, there is still debate about the effectiveness of training on a mini-trampoline. Just as the mini-trampoline craze was fading in 1990, two studies were released stating that rebounding wasn't as effective as previously thought. Gerberich et al. (1990) looked at the effects of rebounding in 17 sedentary women. Subjects performed two separate 18-minute graded exercise tests (GXT), one on a treadmill and one on a mini-trampoline. Stages were 3 minutes long and increased in intensity based on number of steps or bounces per minute. Researchers found that during the trampoline test, HR and VO_2 decreased as bounce frequency increased, whereas in the treadmill test HR and VO_2 increased with step frequency. This trend was also seen in the RPE during each test; on the trampoline RPE decreased as bounce frequency increased, and on the treadmill RPE values increased as step frequency increased. It was also noted that the $\text{VO}_{2\text{max}}$ attained during the trampoline test was only 76% of the $\text{VO}_{2\text{max}}$ achieved on the treadmill, and the $\text{VO}_{2\text{max}}$ obtained from the trampoline test was 80% of the $\text{VO}_{2\text{max}}$ from the maximal treadmill exercise test. From these findings it was determined that rebounding is actually less effective than jogging (Gerberich, et al. 1990).

Also in 1990, Edin et al. researched the effectiveness of chronic mini-trampoline training. This team was specifically looking at changes in cardiorespiratory endurance, blood lipids, and body composition in sedentary women aged 18-40. The 17 subjects were randomly assigned to either an exercise or a control group. All subjects had a pre-study health evaluation and GXT as well as blood tests to establish baseline

measurements. Subjects in the exercise group completed 11 weeks of training on the rebounder for 5 days/week. Exercise sessions consisted of two, 15-minute bouts of exercise with a 5-minute break. During exercise sessions, subjects jogged or bounced at a frequency sufficient to keep their HR in their established “training zone” (70-85% of HR max from GXT). Researchers found a small increase in VO_2max (4.4%) for the exercise group compared to the control group. However, there were no significant changes to blood lipids or body composition.

Recently, mini-trampolines have seen a resurgence in their popularity as an aerobic training method, as more recent studies have attempted to evaluate its effectiveness. However, none of these studies compare the physiological responses to rebounding to established guidelines for aerobic activity.

Mini-Trampoline Training in Athletes

In a slightly different direction than the research of the past, Heitkamp et al. (2001) began looking at the strength increases that could be incurred by a balance-training program without an accompanying strength-training program. Subjects were randomly assigned to either the balance-training program or the strength-training program. Those in the balance-training program performed exercises on a variety of instability devices, including the mini-trampoline. In the strength training group subjects performed strength exercise such as leg curls and leg press. After 6 weeks of training subjects had their balance and leg strength measured. After assessing the results, it was found that balance training on a variety of modalities, including mini-trampolines, resulted in increased balance and leg strength. The balance training also decreased strength imbalances between dominant and non-dominant legs (Heitkamp, et al. 2001).

Building off this idea, researchers began looking at the effects of trampoline training for male-gymnasts. Leg strength and balance are both key factors in the success in gymnastics. Atiligan (2013) examined both static and dynamic balance, as well as leg strength and vertical jump performances. The 28 subjects were randomly assigned to either the trampoline training group or the control group. The subjects in the trampoline training group followed a 1.5 hour program taught by specialized instructors 2 days/week for 12 weeks. The subjects in the control group were not given any exercise to perform. This study found that the most significant improvement by the trampoline training group was in dynamic balance. This research suggests that trampoline training is most effective for the improvement of dynamic balance, rather than leg strength or static balance

Karakollukçu et al. (2014) took a different route of studying the physiological effects of rebounding. Specifically they examined the differences in physiological responses to trampoline exercise between collegiate gymnasts and non-athletes. This study included 20 collegiate gymnasts and 20 non-athletes. All subjects participated in a 12-week trampoline training program. After the training program was completed, subjects showed improvements in their standing long jump, vertical jump, 20-meter sprint speed and anaerobic power production. There was no change in the back strength of subjects after trampoline training.

Special Populations

The use of trampolines as a training method has been studied in a variety of special populations. Going back to a few years after its conception, trampoline training was used to train WWII fighter pilots. They found that training on a trampoline helped to improve the pilot's special awareness and balance, helpful when you're flying through

the air upside-down. A more recent study was performed on fighter pilots looking at training methods to reduce neck-strain. In this study, 16 volunteer Finnish Air Force cadets were randomly assigned to either the strength-training group or the trampoline training group. In the strength-training group subjects performed dynamic flexion and extension exercises and isometric rotation exercises. The trampoline training group performed multiple trampoline bouncing exercises. Subjects performed their assigned training routines for 6 weeks before being retested. There was decreased muscle strain in both groups. From this the researchers concluded that trampoline training and strength training were equally effective at reducing neck strain in fighter pilots. The author does note that since different muscles were more trained in each group, it would be advisable to use both strength training and trampoline training to most significantly reduce neck strain (Sovelius, et al. 2006).

There is a great deal of interest in the use of trampolines in the treatment of cystic fibrosis patients. Since this population is relatively small there are only a few studies on this topic, but those that are have reported positive findings. It began with a small study by Stanghelle et al. (1988) which included only eight subjects. The subjects in the study were children with cystic fibrosis. Each subject participated in three short bouts (approximately 10 minutes) of trampoline exercise each day for 8 weeks. The researchers found that after the training there was a slight increase in FVC and a small, but notable, increase in $VO_2\text{max}$. Subjects were able to increase their $VO_2\text{max}$ from 45 ml/kg/min to 49 ml/kg/min. It was suggested that trampolines be incorporated into the routines of those with cystic fibrosis to help avert monotony and boredom.

Even with this promising research, Barak et al. (2004) disagrees with systemically adding trampolines to the routines of cystic fibrosis patients. After examining the injury reports, he cautions about the risks to children with the use of trampolines. There have not been enough studies showing the benefits of trampoline therapy for children with cystic fibrosis. Until more research is produced, the potential risks of trampoline use appear to outweigh the potential benefits.

Zolaktaf Ghasemi, and Sadeghi (2012) continued the exploration of mini-trampolines as a therapy for patients with asthma. The 37 patients who participated in this study were randomly assigned to a control, rebound, or aerobic group. Subjects completed their assigned training regimen for 45-60 minutes, 2x/week, for 8 weeks. Pre- and post testing was completed to measure for changes in FVC, FEV1, FEV1%, and VO₂peak. Post testing revealed that subjects in both the rebound group and the aerobic group improved on all measures while the control group did not experience any changes in their scores. It was also noted the rebound exercise group had greater improvements than the control group in all areas except FVC.

Going back to looking at the benefits of trampoline training for athletes, Kidgell, Horvath, Jackson, and Semour (2007) evaluated athletes with ankle instability. Balance was assessed pre- and post-training by way of force plate. This machine analyzed the medial-lateral and the anterior-posterior sway paths to determine the stability of each subject. The 20 subjects were randomly assigned to the standard dura disc training group, the experimental mini-trampoline training group or a control group. Subjects completed 6 weeks of balance training on their assigned modality before being reassessed. It was

found that a balance-training program is as effective at reducing postural sway as the standard dura disc training program.

Breaking from the young and well-trained, researchers began to examine the benefits of mini-trampolines for older populations. It is well known that tripping and falling can be very dangerous for older persons, often resulting in serious injury. Due to its well-documented balance-training abilities, Aragão, Karamanidis, and Arampatzis (2011) evaluated mini-trampolines as a strategy to reduce this risk. This study had 22 elderly persons complete 14 weeks of mini-trampoline training, while 12 other subjects served as a control group. Researchers found the benefits of trampoline training to be two-fold. First, the training program increased the strength of plantarflexors in the feet, allowing the subjects to better pick up their feet and reducing the risk of catching their toes as they walked. Secondly, participants who took part in the training program were better able to regain their balance during stumbles helping to avoid a complete fall. Penzer, Duchateau, and Baudry (2014) built on this foundation of using mini-trampolines in the elderly. This team found that although balance training may be beneficial, its effects are increased when it is combined with a strength-training program.

With all the information regarding balance training with mini-trampolines in the elderly, it was only natural to begin looking at stroke patients. Balance is a large concern for stroke patients due to the damage that occurs to the brain during a stroke. Not only did Miklitsch, Krewer, Freivogel, and Steube (2012) analyze the effectiveness of mini-trampolines for this population, they compared it to standing balance program. In each group there was 20 subjects and all subjects participated in 10 sessions on their assigned balance routine. The mini-trampoline group completed their routine while on a mini-

trampoline, whereas the control group completed theirs while standing on the floor. Participants who completed the mini-trampoline routine had significantly increased postural control over those in the control group. Although not as significant, the mini-trampoline also resulted in improved mobility. Both of these measures are associated with greater ability to complete activities of daily living.

There has also been a lot of research done on the lymphatic system and how it is affected by rebounding. The lymphatic system brings nutrients to the cells and helps to clear away cellular waste, therefore it is very important that we keep it moving. Unfortunately, the lymph system does not have a constantly beating pump to circulate its fluid. It relies on movement, skeletal muscle contractions and gravity to make the fluid flow (Scrivens, 2008). The Textbook of Medical Physiology states that activity in the lymph system increases by 10-30 fold during exercise, but at rest it's almost nothing (Guyton & Hall, 2015). The movement as well as muscle contractions are certainly part of why rebounding is seen as one of the best exercises for lymph health. The other major factor that is specific to mini-trampoline training sessions is the effect of gravity. While bouncing your body is continuously being exposed to different amounts of gravitational forces, which also act like a pump helping the lymph system flow more efficiently (Scrivens, 2008).

Risks

Even with all the benefits available from trampolines, risk is still a factor for consideration. Although most trampoline injuries occur on full-sized trampolines, the risk for injury is still present on a mini-trampoline and must be addressed. An analysis performed by Steinbruck & Paelslack (1978) found that although over 7,000 trampoline-

related injuries occur each year, only a very small percentage of those are serious enough to require medical attention. The American Academy of Pediatrics (1999) had similar findings about the number and severity of trampoline related injuries. This report also makes note that a large proportion of injuries occur when participants are practicing tricks or stunts on the trampoline. Additionally, this report noted that many of the injuries from trampolining occur when there are multiple users on the trampoline simultaneously. Due to this risk of injury, several prominent organizations, including the American Academy of Pediatrics and the Canadian Pediatric Society, have released position statements cautioning the use of trampolines (American Academy of Pediatrics, 2015 and Canadian Pediatric Society, 2007).

Britton, a Wisconsin Pediatrician, released a report on the dangers of falls to children (Britton, 2005). He stated that falls are the number one cause of injury to children. He highlights that trampolines are the 4th most frequent recreational activity to result in falls. The activities ahead of trampolines in these rankings are cycling, skateboarding, and roller blading. He does make a point that injuries sustained from falling from a trampoline are typically more severe due to the fact that they are higher off the ground than the other activities.

The only article that addresses the risks associated with mini-trampolines was from Shields, Fernandez, and Smith (2005). They did a comparison of injuries sustained on mini-trampolines and full-sized trampolines over the course of 12 years. Their largest finding was that the vast majority of trampoline injuries happen to children. This analysis found that 82% of injuries from mini-trampolines and 90% of those from full-sized trampolines happened to children less than 18 years of age. They also found that the

group most at risk of injury from a mini-trampoline was children younger than 6 years old. This could be due to the fact that most full-sized trampolines come with a warning label that specifically warns against children under 6, whereas the warning labels on mini-trampolines don't always warn of their risk to children. Injuries resulting from the mini-trampoline were relatively minor when compared to those sustaining on a full-sized trampoline. They include head lacerations, contusions and fractures as well as lower extremity strains and sprains. Injuries resulting from a mini trampoline were also less likely to result in hospitalization than those sustained from a full sized trampoline

Relative Intensity of Mini-Trampoline Training

The most recent version of the Compendium of Physical Activities is one way to gauge relative intensity of different activities (Ainsworth, et al. 2000). It lists various activities and their measured caloric cost. It lists jogging on a mini-trampoline as 4.5 METS, whereas jogging in place is 8 METs meaning that running in place is nearly twice as costly in terms of energy expenditure.

REFERENCES

- Ainsworth, B.E., Haskell, W.L., Whitt, M.C. Irwin, M.L., Swartz, A.M., Stratch, S.J., O'Brien, W.L., Basset, Jr. D.R., Schmitz, K.H., Emplainscourt, P.O., Jacobs, Jr. D.R., Leon, A.S. Compendium of Physical Activities: An Update of Activity Codes and MET Intensities. *Medicine & Science in Sports & Exercise*. 2000.
- American Academy of Pediatrics. Policy Statement: Trampoline Safety in Childhood and Adolescence. *Pediatrics*. 2015.
- American Academy of Pediatrics: Committee on Injury and Poison Prevention and Committee on Sports Medicine and Fitness. Trampolines at Home, School, and Recreational Centers. *Pediatrics*. 1999.
- American College of Sports Medicine. Quantity and Quality of Exercise for Developing and Maintaining Cardiorespiratory, Musculoskeletal, and Neuromotor Fitness in Apparently Healthy Adults: Guidance for Prescribing Exercise. *Medicine & Science in Sports & Exercise*. 2011.
- American College of Sports Medicine. American College of Sports Medicine Position Stand: Appropriate physical activity intervention strategies for weight loss and prevention of weight regain for adults. *Medicine & Science in Sports & Exercise*. 2009.
- Aragão, F.A., Karamanidis, K., Vaz, M.A., Arampatzis, A. Mini-Trampoline Exercise Related to Mechanisms of Dynamic Stability Improves the Ability to Regain Balance in Elderly. *Journal of Electromyography and Kinesiology*. 2011.
- Atiligan, O.E. Effects of Trampoline Training on Jump, Leg Strength, Static and Dynamic Balance of Boys. *Science of Gymnastics Journal*. 2013.
- Barak, A., Wexler, I.D., Efrati, O., Bentur, L., Augarten, A., Mussaffi, H., Avital, A., Rivlin, J., Aviram, M., Yahav, Y., Kerem, E. Trampoline Use as Physiotherapy for Cystic Fibrosis Patients. *Pediatric Pulmonology*. 2005.
- Bhattacharya, A., McCutcheon, E.P., Shvartz, E., Greenleaf, J.E. Body Acceleration Distribution and O₂ Uptake in Humans During Running and Jumping. *Journal of Applied Physiology*. 1978.
- Borg, G. (1998). Borg's Perceived Exertion and Pain Scales. Champaign, IL: Human Kinetics

- Britton, J.W. Kids Can't Fly: Preventing Fall Injuries in Children. *Wisconsin Medical Journal*. 2005.
- Canadian Paediatric Society. Position Statement: Trampoline Use in Homes and Playgrounds. *Paediatrics and Child Health*. 2007.
- Edin, J.B., Gerberich, S.G., Leon, A.S., McNally, C., Serfass, R., Shaw, G., Moy, J., Casal, D. Analysis of the Training Effects of Minitrampoline Rebounding on Physical Fitness, Body Composition, and Blood Lipids. *Journal of Cardiopulmonary Rehabilitation*. 1990.
- Esposito, P.W. and Esposito, L.M. The Reemergence of the Trampoline as a Recreational Activity and Competitive Sport. *Current Sports Medicine Reports*. 2009.
- Gerberich, S.G., Leon, A.S., McNally, C., Serfass, R., Edin, J.B. Analysis of the Acute Physiologic Effects of Minitrampoline Rebounding Exercise. *Journal of Cardiopulmonary Rehabilitation*. 1990.
- Guyton and Hall. Textbook of Medical Physiology. 2015.
- Heitkamp, H.C., Horstman, T., Mayer, F., Weller, J., Dickhuth, H.H. Gain in Strength and Muscular Balance After Balance Training. *International Journal of Sports Medicine*. 2001.
- Karakollukçu, M., Aslan, C.S., Paoli, A., Bianco, A., Sahin, F.N. Effects of Mini Trampoline Exercise on Male Gymnasts' Physiological Parameters: A Pilot Study. *The Journal of Sports Medicine And Physical Fitness*. 2012.
- Kidgell, D.J., Horvath, D.M., Jackson, B.M., Seymour, P.J. Effect of Six Weeks of Dura Disc and Mini-Trampoline Balance Training on Postural Sway in Athletes with Functional Ankle Instability. *Journal of Strength and Conditioning Research*. 2007.
- McGlone, C., Kravitz, L., Janot, J.M. Rebounding: A Low-Impact Alternative. *ACSM's Health and Fitness Journal*. 2002.
- Miklitsch, C., Krewer, C. Freivogel, S., Steube, D. Effects of a Predefined Mini-Trampoline Training Programme on Balance, Mobility and Activities of Daily Living After Stroke: A Randomized Controlled Pilot Study. *Clinical Rehabilitation*. 2013.
- Penzer, F., Duchateau, J., Baudry, S. Effects of Short-Term Training Combining Strength and Balance Exercises on Maximal Strength and Upright Standing Steadiness in Elderly Adults. *Experimental Gerontology*. 2015.
- Scrivens, D. Rebounding: Good for the Lymph System. *Well Being Journal*. 2003.

- Shields, B.J., Fernandez, S.A., Smith, G.A. Comparison of Minitrampoline- and Full-Sized Trampoline-Related Injuries in the United States, 1990-2002. *Pediatrics*. 2005.
- Sovellius, R., Oksa, J., Rintala, H., Huhtala, H., Ylinen, J., Siitonen, S. Trampoline Exercise vs. Strength Training to Reduce Neck Strain in Fighter Pilots. *Aviation, Space, and Environmental Medicine*. 2006.
- Stanghelle, J.K., Hjeltne, N., Bangstad, H.J., Michalsen, H. Effect of Short Bouts of Trampoline Exercise During 8 Weeks on the Pulmonary function and Maximal Oxygen Uptake of Children with Cystic Fibrosis. *International Journal of Sports Medicine*. 1988.
- Steinbrück, K. and Paelslack, V. Trampoline Jumping – A Dangerous Sport? Analyses of Injuries and Preventative Measures. *Münchener Medizinische Wochenschrift*. 1978.
- White, J.R. Changes Following Ten Weeks of Exercise Training Using a Minitrampoline in Overweight Women. *Journal of Medical Science in Sports and Exercise*. 1980.
- Zolaktaf, V., Ghasemi, G.A., Sadeghi, M. Effects of Exercise Rehab on Male Asthmatic Patients: Aerobic Verses Rebound Training. *International Journal of Preventative Medicine*. 2013.