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The Effect of Step Height on Energy Cost Using a Stairmaster 4000PT

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THE EFFECT OF STEP HEIGHT ON ENERGY COST USING A STAIRMASTER 4000PT

by

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THE EFFECT OF STEP HEIGHT ON ENERGY COST USING A STAIRMASTER 4000PT

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Western Michigan University, 1994

The study determined if energy cost or heart rate was affected by Stairmaster 4000PT users stepping at lower than the prescribed 8.0 in. recommended by the manufacturer. Eight women participated in the study. Subjects exercised on the Stairmaster 4000PT using three different step heights; 4.0 in., 6.0 in., and 8.0 in. The condition order was randomized to minimize bias. Subjects stepped with a metronome to regulate step height.

The findings indicated that a lower than recommended step height did not affect energy cost or heart rate.

It was concluded that users may step at any of the three step heights indicated and still attain the desired results provided that arm support is not employed.

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CHAPTER I

INTRODUCTION

The Stairmaster 4000PT exercise machine has become a primary source of aerobic exercise for many adults. The machine adjusts to fourteen intensity levels thus providing an aerobic workout across a variety of conditioning levels.

The manufacturer recommends a step height of 8.0 in., although the machine will accept step heights ranging from 2.0 to 14.0 in. Observation of users and research done using the machine indicated that a wide variety of step heights are commonly used.

Since a shorter step height results in a greater frequency of steps, the actual work done should remain constant. However, a slower step frequency, resulting in a greater step height, requires a greater amount of hip, knee, and ankle flexion, and may increase energy cost.

Statement of the Problem

Most people who use the Stairmaster 4000PT step at a faster rate, thus they use a shorter step height than the manufacturer recommends. Since the manufacturer estimated user's energy cost based on an 8.0 in. step height, those users stepping at less than an 8.0 in. step height may be using less energy. Users should be able to compare energy costs at various step frequencies and heights.

Purpose of the Study

The purpose of the study was to determine if a faster step frequency resulting in a shorter step height, resulted in lower energy cost than that which is attained using the manufacturer's protocol.

Significance of the Study

Stepping techniques vary greatly among individuals. Most users support their body weight with their arms which the manufacturer indicated will reduce energy cost. They also vary their frequency of steps significantly.

A pilot study of 27 individuals was completed. The manufacturer recommended a step height of 8.0 in. The step height range for 15 male users was 3.94 in. to 7.88 in. with a mean of 5.60 in. Twelve female subjects showed a range of 3.28 in. to 8.09 in. with a mean of 4.49 in. Of the 27 individuals observed, only two exceeded 7.0 in. Very few people seem to follow the recommended protocol indicated by the manufacturer.

At the conclusion of the exercise routine, the machine displays an Exercise Summary mode that provides readouts relative to the work done. The number of equivalent floors climbed and equivalent miles covered are simple calculations of work performed. The estimate of calories used is based on an 8.0 in. step using no hand support. The user who supports their body weight and takes small frequent steps may not be actually expending as many calories as the machine indicates. It has been established that arm support affects energy cost. It must be determined if step height has a similar influence on energy cost and to what extent.

Delimitations

Eight females were used for this study due to the greater range of step frequencies chosen by the female subjects in the pilot study. The subjects were conditioned Stairmaster 4000PT users between 21 and 28 years of age. This controlled any learning or training effect over the series of trials.

Limitations

Subjects stepped in cadence with a metronome which controlled step height by controlling step frequency. If the subject had difficulty staying with the metronome, step heights may have varied slightly. Participants used only fingertips to help maintain balance. Some subjects experienced slight difficulty because of their inexperience in using the machine without hand support.

Basic Assumptions

The Stairmaster 4000PT software revision 2.2 indicated the step frequency for an 8.0 in. step. Using this information, the step frequency for a 4.0 in. step and a

6.0 in. step was calculated.

Research Hypothesis

A Stairmaster 4000PT user who stepped at a cadence which results in an 8.0 in. step would expend more energy than one who stepped at a faster cadence, thus a smaller step height.

Definition of Terms

The following terms and definitions were pertinent to the understanding of this study:

1. Step frequency - the number of individual steps taken in one minute.

2. Step height - The height of the step based on how far the chain travels over the sprocket.

CHAPTER II

REVIEW OF LITERATURE

Stairclimbing machines have become a very popular form of aerobic exercise. Machines are designed to fit people of all ages and fitness levels.

The Stairmaster 4000PT exercise machine manufactured by Stairmaster Sports Medical Products, Inc., is a vertical climbing machine that claims to provide an aerobic workout equivalent to actual stairclimbing Stairmaster Inc. (1992). While the literature certainly supports the aerobic effectiveness of the machine, there is a wide variety of techniques employed by regular users. Controlling these variables is essential in determining the actual energy cost of the machine. This chapter is divided into two sections: (1) aerobic exercise guidelines and (2) technique implications.

Aerobic Exercise Guidelines

Aerobic exercise is continuous, large muscle movement that has the effect of raising the heart rate thus strengthening the cardiovascular system while consuming large amounts of energy. Aerobic exercise is commonly based on the exerciser monitoring their heart rate to insure that it falls within a target zone, generally between 60 and 85 % of their estimated maximal heart rate. If the user stays at that intensity level, their heart rate is considered to be at a steady state and the benefits associated with aerobic exercise are usually achieved. If the intensity varies during the exercise, the heart rate may fluctuate and the energy cost becomes more difficult to determine.

Technique Implications

The Stairmaster 4000PT exercise machine is relatively easy to use. The subject stands on two pedals and tries to step normally so the pedal hits neither the top bumper or the floor. Users have a choice of fourteen intensity levels.

The step height range indicated by the manufacturer is 2.0 to 14.0 in. Hand supports are conveniently located to the side of the user to assist with balance if necessary. These two variables seem to influence energy cost considerably. A study by Luketic, Hunter and Feinstein (1993) did not monitor either factor and showed that Stairmaster 4000PT exercise has a lower energy cost than indicated by the manufacturer. The researchers felt that both factors played a role in the diminished energy cost.

Howley, Colacino and Swenson (1992) showed that hand support reduced the energy cost significantly. They quantified hand support as "no hold", "light hold", or "heavy hold". The light hold condition allowed subjects to use fingertips on the frame to assist with balance. There was no difference in energy cost between "no hold" and "light hold". The "heavy hold" treatment showed a significantly lower energy cost.

Several studies looked at step height using a variety of techniques. Hart, Clifton, Crews, Williams and Morgan (1992) used a mechanical restraining devise to limit step heights to 5.0, 8.0, or 11.0 in. They also allowed subjects to step at a freely chosen height. Their study showed that a shorter step height is the most efficient way to exercise on the machine. The energy cost of the freely chosen condition was very similar to the 11.0 in. step height.

Gegel and Brown (1992) showed a lower energy cost when subjects exercised at a 5.0 in. step height compared to a 10.0 in. step height. Step height was visually monitored to insure compliance. Oxygen consumption was 4.8 % higher with the 10.0 in. step condition.

A study by Butts, Dodge and McAlpine (1993) had subjects step in time with a metronome at four predetermined intensity levels. The metronome was set at the cadence the manufacturer indicated would result in an 8.0 in. step. They then compared those findings to a self selected step height. They found no significant difference in energy cost , but they also failed to quantify the self selected step height. An observation made during a pilot study by this researcher indicated that many subjects increase their step height when being observed; possibly because they feel that higher steps are more difficult and follows the protocol better.

Howley, et al. (1992) compared step cadences over 3 intensity levels. They chose their cadences based on a pilot study determining a "slow" and "fast" speed for each work level. Based on the cadences for 8.0 in. steps found in computer version 2.1 and later, the actual step heights they chose varied considerably. At the first intensity level, step heights were 4.3 in. and 3.5 in. At the second level, heights were 6.9 in. and 5.2 in. Level three heights were 8.6 in. and 6.5 in. They indicate no difference in heart rate or energy cost based on step heights.

The need still exists to compare different, consistent, predetermined step heights, at the same intensity levels using a metronome for cadence. Since cadence is the way the manufacturer quantifies step heights, monitoring cadence was the most feasible way to insure step height consistency.

CHAPTER III

DESIGN AND METHODOLOGY

The purpose of the study was to determine if faster step frequency resulting in shorter step heights resulted in lower energy cost than the manufacturer's recommended 8.0 in. step height. This chapter is organized into five content areas: (1) subjects, (2) instrumentation, (3) procedures, (4) calculation of energy cost and (5) data analysis.

Subjects

Subjects that participated in the study were 8 female volunteers between the ages of 21 and 28 years of age. The subjects were regular users of the Stairmaster 4000PT for aerobic exercise.

The study was approved by the Human Subjects Institutional Review Board at Western Michigan University. The approval form is presented in Appendix A. Prior to data collection, the subjects filled out a written questionnaire about their health status. The procedures were explained to them, and they indicated they had no health risks that would prevent them from participating in the study. Consent forms were signed by the subjects. A copy of the consent form is included in Appendix B.

Instrumentation

The metabolic cart used was the Quinton Q-Plex 1. A Bosch EKG501A heart rate monitor was used with a Bosch ECS502 digital display. The subjects exercised on a Stairmaster 4000PT exercise machine with computer software revision 2.2.

Procedures

The research problem was to determine if using a faster step rate, thus a smaller step height, would result in decreased energy cost. Each subject was analyzed using 8.0 in., 6.0 in., and 4.0 in. step heights during three separate trials.

Subjects were asked not to exercise prior to the test on each of the 3 trial days. They were also asked not to eat, drink, use tobacco, or consume caffeine for 2 hours prior to each test.

Subjects were not allowed to use arm support. They were allowed to touch the handrails with their fingertips for balance only. They were given time to warm up, and familiarize themselves with this technique.

For the first trial, subjects were randomly assigned a step height. To achieve that step height, they were required to step at the cadence indicated in Appendix C for the appropriate intensity level. The chart was prepared by multiplying the manufacturer's cadence, times the 8.0 in. step height, and dividing by 4.0 or 6.0 in. step heights to determine the desired cadence. The metronome was calibrated during each trial to insure that the cadence was correct. Subjects were visually monitored to insure that they stayed in step with the metronome.

Subjects began stepping at level 4 on the Stairmaster 4000PT. This intensity level was chosen because it is low enough that an experienced user would be at or below 70% of their maximal heart rate based on 220 minus age.

If after 3 minutes their heart rate stayed within 5 beats, they were considered to have reached a steady state heart rate. If the subject was below 70% of maximal heart rate, the intensity level of the machine was adjusted upward one or two levels depending on how close they were to reaching 70% of their maximal heart rate. The same procedure was repeated until they reached steady state at approximately 70% of maximal heart rate. The setting was recorded as their testing intensity level. Subsequent trials would also be held at this intensity.

Expired air was analyzed for the duration of the time on the machine using an automated open circuit gas system to determine ventilation volumes, absolute and relative oxygen consumptions, and respiratory exchange ratios. When subjects were determined to have reached steady state heart rate, the measures from the metabolic cart recorded every 20 seconds during the 3 minutes were averaged to determine energy cost. Subject's heart rate at the beginning of the 3 minutes, and the end of each minute was recorded and averaged.

The second trial was at least 72 hours after the first trial at approximately the same time of day. Subjects were allowed to warm up at a lower intensity level. They then began stepping at the testing intensity level. For the second trial, subjects were randomly assigned a step height different from that in the first trial. Data were collected the same as in the first trial.

The third trial was at least 72 hours after the second trial. The same procedures were used. The step height was the one not previously used.

Calculation of Energy Cost

The energy cost of the exercise was found by averaging VO2 measurements taken every 20 seconds for 3 minutes, during the subject's period of steady state heart rate. The respiratory exchange ratio (R) measurement was also averaged over the same time period. The kcal cost of the R value from Lusk (1928) was multiplied by the oxygen cost to determine average per minute energy cost for the session. Four heart rates, taken during the 3 minute period, were also averaged.

Data Analysis

Data analysis was completed using a repeated measures design. The dependent variables were energy cost and heart rate. The independent variable was step cadences for 4.0, 6.0, and 8.0 in. step heights.

Data comparisons were made to determine how energy cost and heart rate differed between the 3 trials.

CHAPTER IV

RESULTS AND DISCUSSION

This chapter summarizes the results obtained from the present study and discusses the implication for users to gain the most benefit while using the Stairmaster 4000PT. The purpose of the study was to determine if a faster step frequency resulting in a shorter step height, requires less energy expenditure than the recommended frequency and step height. The goal was to determine if there was a difference in heart rate or energy cost between the recommended protocol and the techniques most often used.

Results

The raw data analyzed were the average steady state heart rate of the users and the average energy cost per minute during steady state. One way repeated measure analyses of variance (ANOVA) were used to analyze the dependent variables, heart rate and energy cost. The independent variable for each dependent variable was step height. The design constituted three step heights; 4.0 in., 6.0 in., and 8.0 in.

Heart Rate

Heart rate for each subject was measured when a steady state was reached. The mean heart rates for subjects using 4.0 , 6.0 or 8.0 in. steps were 144.9, 146.1, and 144.3 beats per minute, respectively. There was no significant difference between mean heart rates at the three step heights, $F(2, 14) = 0.06$, $p < .05$. The standard deviations were 11.4, 8.2, and 15.7 beats per minute for the 4.0 in., 6.0 in., and 8.0 in. step heights, respectively. Table 1 reports the descriptive data for heart rate. Table 2 contains the ANOVA summary for heart rates at the three step heights.

Energy Cost

Energy cost for each subject was measured when a steady state heart rate was reached. The mean energy cost for subjects using 4.0, 6.0, or 8.0 in. steps were 8.34, 8.28, and 8.39 kcal per minute, respectively. There was no significant difference between mean energy costs at the three step heights, $F(2, 14) = 0.17$, $p < .05$. The standard deviations were 1.42, 1.10, and 1.12 kcal per minute for the 4.0, 6.0, and 8.0 in. step heights, respectively. Table 3 reports the descriptive data for energy cost. Table 4 contains the ANOVA summary for energy cost at the three step heights.

Table 1

Descriptive Data for Heart Rate

Step Height (in.)	M (bpm)	SD (bpm)
4.0	144.9	11.4
6.0	146.1	8.2
8.0	144.3	15.7

Discussion

The subjects in this study were experienced female Stairmaster users. There was considerable difference between subjects. The intensity necessary to achieve their target heart rate varied from level four to level ten. Each subject was tested using the same procedures. The only difference was the order of step heights used during their three trials.

Table 2

ANOVA Summary for Heart Rate

Source	SS	df	MS	f
Btw Treatments	13.06	2	6.53	0.06
Btw Subjects	1647.16	7	235.30	2.25
Residual	1464.14	14	104.58	
Total	3124.37	23		

The data collected indicated that there were no differences between step heights regarding energy cost or heart rate. The manufacturer stated that the machine compensated for different step heights; thus, energy cost was not affected. This was a reasonable assumption in that if the user took smaller steps he would take more frequent steps; thus, the amount of work (force times distance) performed would not vary.

Table 3

Descriptive Data for Energy Cost

Step Height (in.)	M (kcal)	SD (kcal)
4.0	8.34	1.42
6.0	8.28	1.10
8.0	8.39	1.12

Table 4

ANOVA Summary for Energy Cost

Source	SS	df	MS	f
Btw Treatments	0.04	2	0.02	0.17
Btw Subjects	29.17	7	4.16	28.70*
Residual	2.03	14	0.14	
Total	31.26	23		

*$p < .05$

Still, if one watched regular users of the Stairmaster 4000PT, you couldn't help but notice that the vast majority took much smaller steps than recommended. Some users may have taken smaller steps due to knee discomfort with larger steps. It would be fair to assume, however, that unless it was somehow easier to take small steps, a random sampling would show a wider range of step heights.

The one factor that may account for the lower step heights was removed in this study, using arm support. It was established that arm support did decrease energy cost.

When a user supported their body weight with locked arms, as many did, it made it very difficult to use large steps. Since the arms were supporting the upper body, large steps made the user rock from side to side while stepping. This would make for a very unnatural gait, thus small steps are called for when using arm support.

Another observation during the course of the study was that the subjects seemed most comfortable with one of the step heights and had more difficulty doing the others. Data was not kept regarding this aspect, but it would be interesting to see if energy cost varied based on whether the subject was using the preferred versus non-preferred step height.

The information derived from this study verified that step rate, which determined step height, did not change the effectiveness of the exercise regarding energy cost or heart rate. Assuming that arm support was not employed, the user could step at 4.0, 6.0, or 8.0 in. step heights and receive the same effect.

CHAPTER V

SUMMARY, FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The Stairmaster 4000PT provided an efficient means of aerobic exercise when utilized correctly . The recommendations of the manufacturer were seldom employed by the average user however. There was a wide range of possible step heights and most users stepped at a lower height than recommended.

The purpose of this study was to determine if a user taking smaller than 8.0 in. steps had a lower energy cost or heart rate than one following the recommended protocol. Eight subjects were tested over three step heights; 4.0, 6.0, and 8.0 in. heights.

Findings

There was no significant difference for energy cost or heart rate between the recommended 8.0 in. step height and 4.0 or 6.0 in. step heights. The manufacturer's assertion that step height did not diminish effectiveness of the exercise was found to be accurate.

Conclusions

Many users of the Stairmaster 4000PT took smaller steps than recommended. As long as they were not using arm support, they could have stepped at 4.0 in., 6.0 in. or 8.0 in. Step heights and had an effective workout. Many users were probably taking small steps because arm support limited the possible range of comfortable step heights. Without arm support, step heights of 4.0 in. or 6.0 in. did not diminish the effectiveness of the exercise.

Recommendations

Most users find a comfortable step height and use it regularly while exercising. Further study should be done to determine if energy costs fluctuate if subjects are forced to use a step height they are not accustomed to using.

Appendix A

Human Subject Institutional Review Board Acceptance Form

Human Subjects Institutional Review Board

Kalamazoo, Michigan 49008-3899
616 387-8293

WESTERN MICHIGAN UNIVERSITY

Date: March 9, 1994

To: Bruce Patnoudes

From: M. Michele Burnette, Chair

Re: HSIRB Project Number 94-02-04

This letter will serve as confirmation that your research project entitled "The effect of step height on energy cost while using the Stairmaster 4000 PT" has been **approved** under the full category of review by the Human Subjects Institutional Review Board. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the application.

You must seek reapproval for any changes in this design. You must also seek reapproval if the project extends beyond the termination date.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: March 7, 1995

xc: Dawson, HPER

Appendix B

Informed Consent Form

Western Michigan University
Department of HPER
The effect of step height on energy cost using a Stairmaster 4000PT
Dr. Mary Dawson
Bruce Patnoudes

I have been invited to participate in a research project entitled "The effect of step height on energy cost using a Stairmaster 4000PT." I understand this experimental research is intended to compare energy cost of individuals while stepping at three different step heights. I further understand that this project is Bruce Patnoudes' Master's Thesis project.

By consenting to participate in this project I know that I will be asked to attend three 45 minute sessions in the exercise physiology laboratory at Western Michigan University. During these sessions I will be asked to use the Stairmaster 4000PT exercise machine that I have indicated I regularly use. I will be hooked up to a heart rate monitor which consists of placing electrodes on my chest. I will breathe into a tube to analyze my oxygen intake. I will be asked to exercise at a sub maximal heart rate for a period of approximately 6 to 15 minutes during each session. Sub maximal heart rate means the intensity will be similar to the intensity that I normally achieve while exercising. The data will be used to determine if different step heights affect energy cost while using the Stairmaster 4000PT.

I am experienced in the use of the Stairmaster 4000PT exercise machine, and I understand I will be exercising within generally accepted heart rate ranges. I understand one potential risk being that I may not use arm support while exercising but I may use my fingertips for balance if I so desire. I further understand that I will be given time to practice this technique if I am not familiar with it. I understand the risks associated with this study are no greater than those expected of routine exercise.

I understand that as in all research, there may be unforeseen risks to me. If an accidental injury occurs, appropriate emergency measures will be taken: however no compensation or treatment will be made available to me except as otherwise stated in this consent form.

I understand that there are no direct benefits to me for participating in this study. I understand that all information in this study is confidential. I will be given a code number which will be used to identify my results. A separate master list of names will be kept only until the data is analyzed, after which time it will be destroyed. My name will not be used on any papers related to this study.

I understand that I may refuse to participate or quit at any time during the study without prejudice or penalty. If I have any questions or concerns about this study, I may contact Bruce Patnoudes at 616-429-9727 or Dr. Dawson at 387-2669. I may also contact the Chair, Human Subjects Institutional Review Board at 387-8293, or the Vice President for research, if questions or problems arise during the course of this study.

I have read the statement above and have had all my questions answered.

Signed____Date______________

Appendix C

Step Height Cadences

Step Height Cadences

Intensity level	Manufacturer's Cadence for 8" steps	Cadence for 6" steps	Cadence for 4" steps
1	26	35	52
2	35	47	70
3	43	57	86
4	52	69	104
5	60	80	120
6	69	92	138
7	77	103	154
8	86	115	172
9	95	127	190
10	103	137	206
11	112	149	224
12	121	161	242
13	129	172	258
14	138	184	276

Appendix D

Raw Data

Subject # 1 Age 22 70% max HR 139
Weight 156

Trial 1 Step Ht. 6 in.

Level	1 min	2 min	3 min	4 min	5 min
4		143	146	152	
	6 min	7 min	8 min	9 min	10 min
	154	156	157		

Trial 2 Step Ht. 4 in.

Level	1 min	2 min	3 min	4 min	5 min
4	130	138	143	144	147
	6 min	7 min	8 min	9 min	10 min
	152	153	151	152	151

Trial 3 Step Ht. 8 in.

Level	1 min	2 min	3 min	4 min	5 min
4	143	153	155	161	161
	6 min	7 min	8 min	9 min	10 min
	166	168	166	168	

Subject # 2 Age 24 70% max HR 137
Weight 116

Trial 1 Step Ht. 6 in.

Level	1 min	2 min	3 min	4 min	5 min
4			128		
	6 min	7 min	8 min	9 min	10 min
5	135	137	136	136	136

Trial 2 Step Ht. 4 in.

Level	1 min	2 min	3 min	4 min	5 min
5	115	115	122	121	123
	6 min	7 min	8 min	9 min	10 min
	124				

Trial 3 Step Ht. 8 in.

Level	1 min	2 min	3 min	4 min	5 min
5	141	140	146	147	150
	6 min	7 min	8 min	9 min	10 min
	151	154	154		

Subject # 3 Age 23 70% max HR 138
Weight 128

Trial 1 Step Ht. 8 in.

Level	1 min	2 min	3 min	4 min	
4	111	109	114	114	
	5 min	6 min	7 min		
6	130	130	130		
	8 min	9 min	10 min	11 min	12 min
7	143	141	149	151	154
	13 min				
7	151				

Trial 2 Step Ht. 6 in.

Level	1 min	2 min	3 min	4 min	5 min
7	135	136	139	140	142
	6 min	7 min	8 min	9 min	10 min
	145				

Trial 3 Step Ht. 8 in.

Level	1 min	2 min	3 min	4 min	5 min
7	137	138	139	145	147
	6 min	7 min	8 min	9 min	10 min
	150	152	155	155	156

Subject # 4 Age 22 70% max HR 139
Weight 113

Trial 1 Step Ht. 4 in.

Level	1 min	2 min	3 min	4 min
4			104	
	5 min	6 min	7 min	8 min
6	125	128	138	140
	9 min	10 min	11 min	12 min
7	148	150	148	150

Trial 2 Step Ht. 8 in.

Level	1 min	2 min	3 min	4 min	5 min
7	144	146	146	151	152
	6 min	7 min	8 min		
	153	156	159		

Trial 3 Step Ht. 6 in.

Level	1 min	2 min	3 min	4 min	5 min
7	138	139	142	145	147
	6 min	7 min	8 min	9 min	10 min
	148	152	153	155	156

Subject # 5 Age 28 70% max HR 134
Weight 136

Trial 1 Step Ht. 6 in.

Level	1 min	2 min	3 min	4 min	5 min
4	140	143	147	150	153
	6 min	7 min			
4	150	148			

Trial 2 Step Ht. 4 in.

Level	1 min	2 min	3 min	4 min	5 min
4	128	130	133	137	135
	6 min				
	135				

Trial 3 Step Ht. 8 in.

Level	1 min	2 min	3 min	4 min	5 min
4	114	116	119	118	120
	6 min	7 min			
	122	122			

Subject # 6 Age 21 70% max HR 139
Weight 156

Trial 1 Step Ht. 6 in.

Level	1 min	2 min	3 min	
4	129	124	127	
	4 min	5 min	6 min	7 min
5	132	137	144	145
	8 min	9 min	10 min	11 min
6	150	151	151	154

Trial 2 Step Ht. 8 in.

Level	1 min	2 min	3 min	4 min	5 min
6	138	136	135	139	144
	6 min	7 min	8 min	9 min	
	149	148	152	152	

Trial 3 Step Ht. 4 in.

Level	1 min	2 min	3 min	4 min	5 min
6	139	146	147	150	155
	6 min	7 min	8 min		
	155	157	159		

Subject # 7 Age 24 70% max HR 137
Weight 116

Trial 1 Step Ht. 4 in.

Level	1 min	2 min	3 min	4 min
4 & 6	100	95	101	100
	5 min	6 min	7 min	8 min
8	120	124	128	140
	9 min	10 min	11 min	12 min
10	148	149	147	148

Trial 2 Step Ht. 8 in.

Level	1 min	2 min	3 min	4 min	5 min
10	129	128	127	127	126

Trial 3 Step Ht. 6 in.

Level	1 min	2 min	3 min	4 min	5 min
10	130	132	133	133	133
	6 min				
	134				

Subject # 8 Age 22 70% max HR 139
Weight 144

Trial 1 Step Ht. 6 in.

Level	1 min	2 min	3 min		
4	114	119	121		
	4 min	5 min	6 min	7 min	8 min
6	130	139	141	144	147
	9 min	10 min			
6	149	149			

Trial 2 Step Ht. 8 in.

Level	1 min	2 min	3 min	4 min	5 min
6	130	128	127	126	131
	6 min	7 min	8 min		
	132	136	134		

Trial 3 Step Ht. 4 in.

Level	1 min	2 min	3 min	4 min	5 min
6	130	135	140	139	141
	6 min	7 min			
	144	144			

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