A Comparison of A Recumbent Stepper versus a Recumbent Bike in Energy Expenditure at a Subject-set Rate of Perceived Exertion: An Investigational Study

N.E. Wolkodoff, F. Stanek

Background: Seated energy training options are gaining popularity because of issues with impact exercise and joint distress as adults get older and need to maintain exercise levels. Recumbent forms of exercise, specifically recumbent bikes and now recumbent steppers, hold promise for providing a meaningful workout in a seated position. What is the energy expenditure difference between a recumbent bike and a recumbent stepper at the same level of effort? A FreeStep, a recumbent cross trainer - a stepper device with arm motion (Teeter, Puyallup, WA), and a Marcy Recumbent Bike, model NS-40502R (Marcy, Pomona, CA) were chosen for the study because they both used a magnetic drive system/resistance with eight levels of resistance. The hypothesis was the more significant leg recruitment of the FreeStep and arm motion would result in higher energy expenditure (EE) level at the same Rate of Perceived Exertion (RPE).

Methods: 31 subjects were recruited for the study (N=31, 14 Male, 17 Female, Average Age, 56.5). Participation required a regular exercise program of at least three days per week, and familiarity with various forms of energy system training typical to athletic/health clubs such as ellipticals and stationary bicycles. Before participation, exercise readiness, medical factors, and suitability were determined. After acceptance, each participant underwent a standard, ramped VO2 max test using a metabolic system and ergometer (Oxycon Mobile and Ergoline ViaSprint Ergometer, Vyaire, Yorba Linda, CA). Each analysis was performed after standard system warm up, and calibration, and watts were increased after warm up based upon body weight in either 10 or 20 watts per minute, so the test duration did not exceed 16 minutes. The termination point was either volitional subject fatigue or a Respiratory Exchange Ratio (RER) of 1.10 or higher, indicating the subject reached a maximum level of exercise.

During the test, RPE was referenced and correlated at the warm-up level, steady-state level, slightly above threshold intensity, and maximum effort. It was theorized this would provide additional familiarity with RPE, as it would be used to later set exercise intensity during the steady-state portion

of the testing. Most individual exercisers use RPE when exercising at home to establish a reasonable level of energy expenditure (EE). During the VO2 profile and the familiarity profiles, the concept of RPE was extensively discussed as it related to exercise intensity and resistance/difficulty levels.

After the VO2 profiles, one session of familiarity training was performed with the new exercise device, the FreeStep for 5-8 minutes to tune distance and seating for the individual while also gaining the subject understanding of the coordinated movement of legs and arms with this device. If there was no recent experience with the recumbent bike, there was an additional familiarity bout with the recumbent bike to understand position, controls and set seat position.

For all exercise trials, subject data was recorded using the same Oxycon Mobile Metabolic System for each trial recording ventilatory, metabolic and basic heart rate data. Trials were 7-10 minutes in duration, which was based both on reaching a steady rate of EE and subject tolerance for that specific exercise bout to complete the four trials. The protocol was to perform two trials on each exercise mode for the steady-state/RPE portion of the study. The subject was instructed to gradually increase the level of resistance or speed until they felt they were at a 6/10 level on the RPE scale. Further instruction included using the same time frame of a two to three-minute ramp up for all four bouts of measurement. Thus if in the first bout the person used two minutes to increase the difficulty in attaining this level, they should use two minutes on the subsequent three trials. Subjects were instructed going from starting to 6/10 is typically accomplished in two to three minutes.

The order of exercise was randomized across the modes of activity, with each successive subject performing the four bouts of exercise in the opposite rotation compared to the previous subject. Thus the first subject might rotate through the four episodes with the order of FreeStep, bike, FreeStep, and bike while the next subject would rotate through the bouts with the order of bike, Free Step, bike, and FreeStep. The RPE scale was also used to aid subjects in recovery between bouts to determine when to start the next episode. In general, subjects rested four to five minutes between sessions, to the point of 2/10, or resting comfortably. Metabolic data for each trial was converted to a metric of kcal per hour for each mode of exercise.

Also, RER data were collected for each trial. This number is the ratio of Oxygen consumed to Carbon Dioxide exhaled. Typically, a number of less than 1.0 indicates the exercise level is "aerobic" or steady state in nature. A ratio of above 1.0 indicates the individual is sprinting to some degree above the cardio-metabolic or anaerobic threshold and using carbohydrates entirely as fuel.

Results: The results from each subject for each trial were recorded based upon total EE from metabolic data, then converted into a kcal-per-hour number. Statistical analysis, using SPSS, did reveal significant trends and relationships between modes of exercise through repeated trials ($p < .001$) for the EE calculations using paired t-tests. The FreeStep consistently across subjects elicited a significantly higher mean EE per hour (322 kcal) than the recumbent bike (266 kcal) at the same subject-directed, RPE level. The RER data also revealed the same trend, mirroring the EE data and relationships thus confirming the higher EE with the FreeStep ($p < .001$).

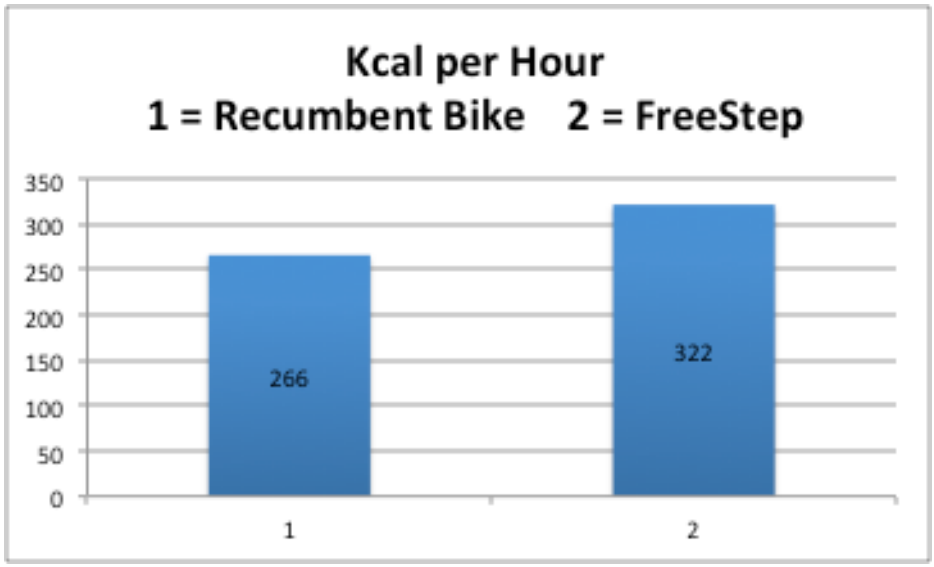
Conclusions: Statistical analysis revealed significant differences in EE for the recumbent bike compared to the FreeStep. It is likely that the increased caloric expenditure for the FreeStep is due to the fact the leg motion elicits more considerable muscular contributions, akin to a leg press motion. Additionally, the contribution of the upper body in the exercise motion likely adds to the increased EE.

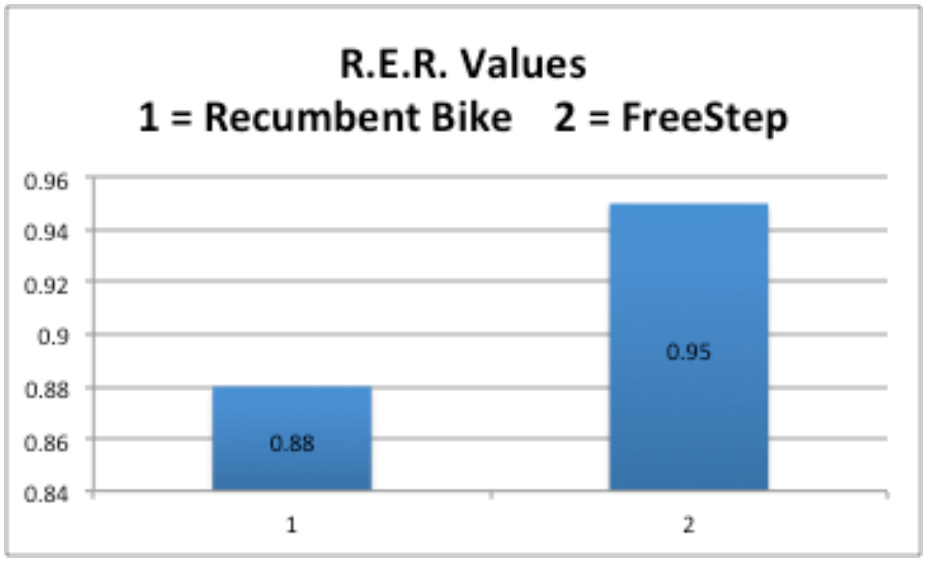
The statistics point to the conclusion that when performed to the same level of RPE, the FreeStep will burn significantly more kcal than a recumbent bike or similar mode of exercise. This is important because it affords those with joint distress (knee, hip, back, and foot), a mode of exercise which is significant in effect, yet will be “easy” on the joints due to the seated position and likely have better exercise compliance and adherence.

Address correspondence inquiries to primary researcher: neil@cochss.com

Table 1: Subject Data: Kcal per trial, RER and Age

Subject	Bike kcal hour	Free Step kcal hour	Bike RER	Free step RER	Age
1	346	372	0.91	0.94	48
	354	418	0.92	0.91	
2	274	283	0.94	0.96	46
	236	292	0.92	0.93	
3	318	347	0.92	0.93	49
	268	315	0.87	0.9	
4	362	537	0.9	0.94	61
	428	468	0.92	0.83	
5	320	363	0.98	0.95	51
	265	364	0.93	0.9	
6	214	271	0.97	1.04	59
	259	286	0.9	1.02	
7	263	295	0.93	0.94	63
	251	286	0.9	0.9	
8	212	239	1.02	0.94	68
	218	240	0.93	0.94	
9	259	297	0.89	0.95	64
	241	351	0.87	0.97	
10	239	358	0.88	0.98	68
	283	401	0.87	0.95	
11	305	374	0.9	1	65
	295	337	0.99	0.96	
12	265	331	0.89	0.91	45
	228	320	0.83	0.92	
13	259	319	0.92	0.91	66
	270	315	0.87	0.92	
14	240	297	0.89	0.94	57
	227	304	0.86	0.93	
15	236	274	0.95	0.95	40
	216	289	0.93	0.92	
16	277	285	0.95	0.92	53
	249	324	0.8	0.96	
17	240	260	0.92	1.02	65
	220	289	0.98	1.01	
18	273	295	0.93	0.99	57
	237	303	0.86	0.91	
19	277	322	0.97	0.98	67
	265	303	0.94	0.96	
20	191	225	1	1.06	56
	220	258	0.92	0.98	
21	319	333	0.87	0.89	58
	275	321	0.87	0.94	
22	219	259	0.95	0.97	57
	250	259	0.9	0.95	
23	311	360	0.89	0.97	55
	337	367	0.95	0.95	
24	267	376	0.89	0.89	44
	293	430	0.88	0.9	
25	276	355	1	1	47
	284	381	0.96	0.98	
26	278	339	0.91	0.97	64
	285	317	0.98	0.93	
27	280	316	0.98	0.94	58
	324	425	0.94	0.93	
28	221	264	0.92	0.95	46
	235	258	0.93	0.94	
29	247	282	0.91	0.93	58
	242	267	0.91	0.93	
30	238	285	0.94	0.97	59
	243	288	0.95	0.96	
31	239	321	0.9	0.94	59
	244	351	0.88	0.95	
Average	266	322	0.92	0.95	56.5


Kcal per Hour
1 = Recumbent Bike 2 = FreeStep
350
300
250
200
150
100
50
0
266
322
1
2


R.E.R. Values
1 = Recumbent Bike 2 = FreeStep
0.96
0.94
0.92
0.9
0.88
0.86
0.84
0.88
0.95
1
2

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Bikekcalhour	266.241935483871000	63	42.426667467324540	5.345257670275015
	FreeStepkcalhour	321.951612903225850	63	56.810502044602934	7.157450488892658
Pair 2	Bikekcalhour	266.241935483871000	63	42.426667467324540	5.345257670275015
	BikeRER	.919032258064516	63	.042529294549771	.005358187467319
Pair 3	FreeStepkcalhour	321.951612903225850	63	56.810502044602934	7.157450488892658
	FreestepRER	.947580645161290	63	.038382013759428	.004835679201205

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Bikekcalhour & FreeStepkcalhour	63	.806	.000
Pair 2	Bikekcalhour & BikeRER	63	-.030	.818
Pair 3	FreeStepkcalhour & FreestepRER	63	-.356	.004

Paired Samples Test

		Paired Differences 95% Confidence Interval of the Difference Upper	t	df	Sig. (2-tailed)
Pair 1	Bikekcalhour - FreeStepkcalhour	-47.204381577514546	-13.093	62	.000
Pair 2	Bikekcalhour - BikeRER	276.008243856813860	49.636	62	.000
Pair 3	FreeStepkcalhour - FreestepRER	335.315018093301200	44.838	62	.000