Exercise Intensity and Substrate Utilization in Healthy Sedentary Females Using the Life-Build-Line Device

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Background: *Life-Build-Line (LBL) is a new exercise device that is convenient, and not so expensive. Together with the style of movement, it may boost one to adhere to the exercise regimen and thereby promote better health. However, no study has proved its exercise intensity and effect on substrate utilization.*

Objective: *To investigate exercise intensity in healthy sedentary women using LBL and measure their substrate utilization during exercise. The former session was determined by measuring absolute [i.e., energy expenditure (EE)] and relative [i.e., percentage of rate of peak oxygen consumption ($\dot{V}O_2$ peak), maximal heart rate (HR_{max}), rating of perceived exertion (RPE), and rating of perceived dyspnea (RPD)] indicators, whereas the latter was determined by measuring oxygen consumption and carbon dioxide production ($\dot{V}CO_2$).*

Material and Method: *Ten female subjects randomly performed two visits of exercise at least seven days apart. The first was a peak exercise test, and the second consisted of three 30-minute sessions of rest, exercise with LBL, and recovery. The $\dot{V}O_2$, $\dot{V}CO_2$, and EE were determined based on the expired air at the last five minutes of resting and exercise, whereas electrocardiograms were recorded to measure HR throughout the three sessions. Subjects were asked to provide RPE and RPD at the end of the exercise session.*

Results: *During exercise with LBL, average %$\dot{V}O_2$ peak and %HR_{max} were 43.5%±2.32% and 52.8%±1.81%, respectively, while EE, RPE, and RPD were 3.01±0.53 metabolic equivalents, 12.2±1.8, and 3.0±1.41, respectively. In addition, fat and especially CHO utilization were increased by the exercise.*

Conclusion: *These findings indicate that LBL offers a means of low-intensity exercise in healthy females while still providing physiological and metabolic benefits.*

Keywords: *Oxygen consumption, Heart rate, Energy expenditure, Exertion, Dyspnea, Women*

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Moderate-intensity exercise has been recommended for promoting health(1-4), since it improves cardiovascular, respiratory, and neuromuscular functioning. Moreover, motivational strategies are important to increase adherence to exercise regimens(5). There is a new, dual-function exercise device known as the Life-Build-Line (LBL) that is convenient and not so expensive; moreover, it boosts one to adhere to the exercise regimen and thereby promote better health.

LBL consists of two rigid or unplasticized polyvinyl chloride (uPVC) pipes connected with an elastic tube (Fig. 1). With the two pipes attached, it can be used as a long uPVC tube for a mode of Thai exercise known as the Wand Exercise(6), whereas the pipes can be removed and the elastic tube connecting

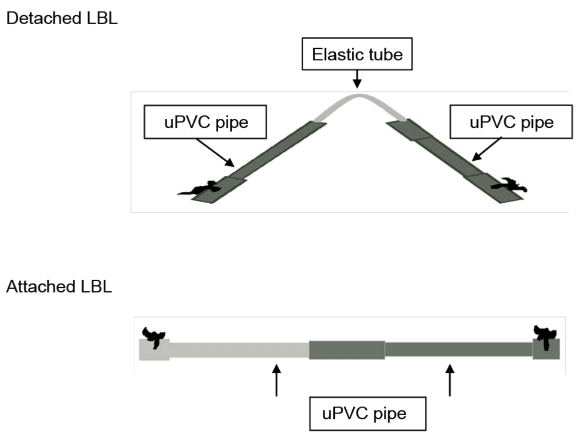

Fig. 1 LBL device.

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the two uPVC tube handles used for a separate exercise. The latter function is of particular interest since the elastic tube provides high resistance.

Exercise with LBL may increase substrate utilization and consequently improve health status and athletic performance[3]. Patients with peritoneal dialysis can use LBL at home to increase waste product removal from the dialysate by abdominal movement. However, there have been no studies exploring the intensity and substrate utilization during exercise with LBL.

The present study examined exercise intensity in healthy sedentary women using LBL and measured their substrate utilization during exercise. The former session was determined by measuring absolute [i.e., energy expenditure (EE)] and relative [i.e., percentage of rate of peak oxygen consumption ($\dot{V}O_2$ peak) and maximal heart rate (HR_{max}), rating of perceived exertion (RPE), and rating of perceived dyspnea (RPD)] indicators; whereas the latter was determined by measuring oxygen consumption and carbon dioxide production. The authors hypothesized that using the elastic tube function of LBL constitutes moderate-intensity exercise that would increase the utilization of carbohydrate (CHO) over fat as an energy source.

Material and Method

The present study was a prospective study measuring the intensity of exercise as indicated by absolute (EE) and relative (percentage of $\dot{V}O_2$ peak and HR_{max}, RPE, and RPD) indicators in healthy sedentary women. It was conducted at Srinagarind Hospital, a tertiary care teaching University hospital affiliated to Khon Kaen University in Khon Kaen, Thailand.

The study protocol was approved by the Ethical Committee of Khon Kaen University, and subscribed to the Declaration of Helsinki in 1995 (HE571342). All participants provided written, informed consent.

The study group consisted of 10 healthy, sedentary women between the ages of 40- and 50-year-old who met the inclusion criteria. The size of the group was selected according to a previous study[7] to meet the requirement of 80% power at a significance level of 0.05. Subjects underwent routine physical and medical examinations, which included medical history screening and health risk and physical activity questionnaires. Anthropometry was carried out using an HBF-375 KaradaScan instrument (Omron Healthcare Co., Kyoto, Japan). All participants had a normal body mass index (18.5 to 22.9 kg/m^2) and no underlying disease, did not regularly engage in moderate- or high-intensity physical activities (30 or less to 60 minutes of moderate-intensity exercise five days/week or 20 minutes or less to 60 minutes of vigorous exercise three days/week), and drank or smoked only occasionally (fewer than two times a week). Exclusion criteria were hypertension (systolic and diastolic blood pressures 140 or greater and 90 mmHg, respectively), cardiovascular or pulmonary disease, diabetes mellitus, orthopedic problems (e.g., bones, joints, and muscle), cancer, renal or hepatic disease, contagious disease, and chronic infection.

LBL

LBL consists of two uPVC pipes connected to an elastic tube (Fig. 1). As described above, it can be used as a long uPVC pipe for the Wand Exercise and as an elastic tube for the elastic tube exercise by removing the pipes.

Study protocol

Subjects were asked to refrain from eating, smoking, or drinking tea, coffee, or alcohol for at least two hours before each exercise visit. They were also requested not to engage in strenuous exercise for 24 hours prior to the trial to ensure a consistent baseline activity.

Before starting the experiment, all the exercise steps/postures were explained to the participants, who then randomly performed two visits of exercise at least seven days apart to prevent carry-over effects; the first was a peak exercise test, and the second consisted of three 30-minute sessions of rest, exercise with LBL (Appendix 1), and recovery.

Visit 1: $\dot{V}O_2$ peak test

On the day prior to the $\dot{V}O_2$ peak test, subjects were advised to get at least eight hours of sleep and were interviewed to ensure that they had not engaged in any intense activity or exercise. The test started with an initial workload of 30 W; the 3-minute workload was increased by 15 to 20 W until HR reached 85% of HR_{max} or until the subject failed to maintain the cycling speed (not lower than 60 rpm) or presented abnormal signs or symptoms such as near syncope, dizziness, or an abnormal electrocardiogram (ECG). The $\dot{V}O_2$ peak was determined from the extrapolation of $\dot{V}O_2$ to predicted maximum HR. When the subjects met these criteria, they were asked to continue cycling for three minutes to relax at a free workload before BP, HR, and O_2 saturation were measured.

Visit 2: exercise with LBL

All subjects performed three 30-minute sessions of rest, exercise with LBL, and recovery. Exercise with LBL consisted of 17 continuous postures, with each posture repeated 20 times within 30 minutes of exercise. The starting position of each posture involved sitting upright on the bed with both hands placed on the LBL handles. Subjects performed the exercise in a seated position with movement of their upper and lower extremities and trunk (Appendix 1).

At the last five minutes of resting and both bouts of exercise, expired air was collected through a face mask connected to a gas analyzer (Oxycon Mobile; BD Biosciences, Franklin Lakes, NJ, USA) configured in the breath-by-breath mode to measure $\dot{V}O_2$, $\dot{V}CO_2$, respiratory exchange ratio (RER), and EE. $\dot{V}O_2$ (L/minute) and $\dot{V}CO_2$ (L/minute) were used to calculate substrate utilization (g/minute) and EE (in metabolic equivalents, MET) while disregarding protein oxidation(8), where EE is the total energy cost. ECG was also monitored with a diascope (type DS 521; Simonsen and Weel, Vallensbæk Strand, Denmark) throughout the two visits of exercise to measure HR. At the end of the exercise sessions, RPE and RPD were asked. The former is a psychophysiological rating of perceived effort, while RPD is used to evaluate shortness of breath during exercise or tasks. $\dot{V}O_2$ and HR during exercise with LBL were calculated as percentage of $\dot{V}O_2$ peak and HR_{max} obtained by the peak oxygen consumption test and with the formula (220 – age). The study was carried out at controlled temperature (25°C±0.5°C) and humidity (50%±0.3%). All measurements were made by the same investigator.

Statistical analysis

Data were expressed as mean ± standard deviation and were analyzed using StatMost v.3.6 software (DataMost, Chatsworth, CA, USA). One-way repeated measures analysis of variance was used to assess differences between phases of exercise with LBL, and a Tukey Post hoc test was used to identify the phase that differed. A $p<0.05$ was considered statistically significant.

Results

Demographic and clinical characteristics of study subjects

All participants were determined to be healthy, non-obese, middle-aged women according to medical history and the results of the health questionnaire and physical examination are shown in Table 1.

Table 1. Physiological characteristics of subjects

Variables	Mean value
Age (year)	45.0±3.69
Body mass index (kg/m^2)	20.7±1.82
Resting heart rate (/minute)	66.4±7.07
Resting blood pressure (mmHg)	105±11.90/62±7.98
Peak oxygen consumption (mL/kg/minute)	28.4±1.58

Physiological and metabolic responses to exercise

During exercise with LBL, all participants showed increases in HR ($p<0.05$, Fig. 2A), $\dot{V}O_2$ ($p<0.05$, Fig. 2B), and RER (Fig. 2C) above the respective resting values; these returned to baseline after recovery. Average values of $\dot{V}O_2$, HR, EE, RPE, and RPD and exercise intensity with LBL were shown in Table 2. The values for $\dot{V}O_2$, HR, and EE indicated that exercise with LBL was of low intensity (Table 2). However, RPE and RPD values suggested that the exercise was of low or moderate intensity (Table 2). In addition, CHO and fat oxidation rates (mg/kg fat-free mass/minute) were higher during exercise with LBL as compared to baseline and recovery values ($p<0.05$, Fig. 3A). More CHO was oxidized than fat during exercise, whereas more fat was oxidized than CHO during recovery ($p<0.05$, Fig. 3A). During recovery, compared with baseline, CHO was less oxidized and fat was more oxidized ($p<0.05$, Fig.3A). In addition, CHO contribution was greater during

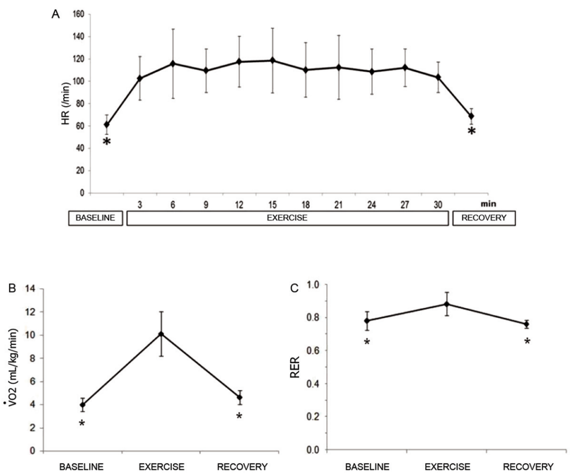

Fig. 2 HR (/minute) recorded at baseline, every 3 minutes of exercise with LBL, and during recovery (A), $\dot{V}O_2$ (mL/kg/minute) (B), and RER (C) baseline, during exercise with LBL, and during recovery (mean ± SD; n = 10). HR = heart rate; $\dot{V}O_2$ = oxygen consumption; RER = respiratory exchange ratio; * $p<0.05$ vs. during exercise.

Table 2. $\dot{V}O_2$, HR, EE, RPE, and RPD during exercise with LBL

Variables	Mean value	Percentage of maximal value	Intensity level
$\dot{V}O_2$ (ml/kg/minute)	10.3±1.10	43.5±2.32	Low
HR (/minute)	108.0±16.0	52.8±1.81	Low
EE (MET)	3.01±0.53		Low
RPE	12.2±1.79		Low/Moderate
RPD	3.0±1.41		Low/Moderate

$\dot{V}O_2$ = oxygen consumption rate; HR = heart rate; EE = energy expenditure; MET = metabolic equivalent; RPE = rating of perceived exertion; RPD = rating of perceived dyspnea
Values are mean ± SD (n = 10).

exercise, whereas fat contribution was greater at baseline and during recovery ($p<0.05$, Fig. 3B). Thus, during recovery, participants relied more on fat for energy, but during exercise, they relied more on CHO ($p<0.05$, Fig. 3B).

Discussion

This is the first study demonstrating that exercise with LBL is of low intensity, as evidenced by $\dot{V}O_2$, HR, and EE. In addition, subjects engaging in LBL exercise relied more on CHO than fat for energy. An exercise is considered as being of low intensity for values of 50% $\dot{V}O_2$ peak, 55% HR_{max}, and 3-MET[9-12]. Although the RPE and RPD in the present study would classify LBL exercise as being moderately intense, previous studies have concluded that these parameters are not sufficiently accurate to be used as indicators[13-15]. RPE is associated with an effective, safe, and reliable conditioning HR above 150/minute (80% HR_{max})[14]. Moreover, it provides a valid means of regulating exercise intensity at 50% and 70% $\dot{V}O_2$ max[13]. The %$\dot{V}O_2$ peak during exercise with LBL in the present study was below 50%; thus, the mean RPE during exercise with LBL may be inaccurate.

The length of time for collecting the expired gas (the last five minutes of the 30-minute exercise session) was relatively short; however, it was appropriate for investigating substrate utilization during exercise in peritoneal dialysis patients and was sufficient for evaluating the rate of fuel oxidation, which occurred after three minutes of exercise. Therefore, the authors considered that measuring oxidation rates in the last five minutes of LBL with constant workload (as determined by 3-minute HR recorded throughout the exercise) represented the whole exercise session.

Although the results did not support our original hypothesis that exercise with LBL was of moderate intensity, the authors did confirm that the exercise increased the utilization of fat and CHO, with a greater effect observed for the latter. On the other hand, fat was used more than CHO during exercise recovery, allowing active muscle to resynthesize intramuscular glycogen. Since fat is greatly utilized during recovery, the exercise training using LBL without feeding during recovery may enable better weight reduction. The oxidation rates of CHO and fat reported here are similar to those of our previous study, which showed that fat oxidation rate was highest during low-intensity exercise[16]; this type of exercise can be used to improve endurance in both healthy sedentary individuals and patients with other diseases. Indeed, this has been shown to benefit patients with type 2 diabetes mellitus[17-20]. Additionally, it is worthwhile to explore the value of exercising with LBL in patients with cardiovascular or metabolic diseases. According to the recommendation of moderate-intensity exercise for improving cardiovascular function, the adjustment of the exercise with LBL aiming to increase its exercise intensity is suggested. This may be successful by increasing the resistance of the elastic tube or weight

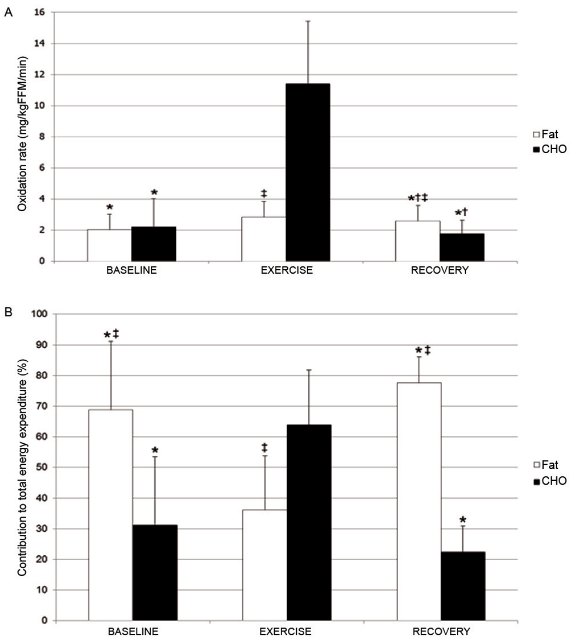

Fig. 3 Substrate utilization during exercise with LBL (mg/kgFFM/minute) (A). Contribution of substrate utilization during exercise with LBL to total energy expenditure (%) (B) (mean ± SD; n = 10). * $p<0.05$ vs. during exercise; † $p<0.05$ vs. before exercise; ‡ $p<0.05$ vs. CHO at the same time point.

of the plastic pipes. The longer duration of the exercise may also be useful for increasing the intensity.

The present investigation was limited by the fact that the study group comprised only female subjects. There was lack of information on gender difference in physiological and metabolic responses to exercise; therefore, further studies investigating responses to exercise with LBL in healthy sedentary men are also needed.

Conclusion

The results of the present study suggest that using the novel LBL device provides a mean of low-intensity exercise in healthy females, and increases substrate utilization, particularly of CHO more than fat during exercise, and fat more than CHO during recovery.

What is already known on this topic?

Healthy sedentary Thais relied more on CHO than fat at rest and during low-intensity exercise. No previous studies have investigated the intensity and substrate utilization exercise with LBL before.

What this study adds?

The present study showed the intensity of the exercise with LBL, a new exercise device in healthy sedentary women is of low level. Moreover, the authors also found that this mode of exercise increases CHO and fat utilization with greater value in CHO during the exercise. In contrast, fat was more utilized than CHO during recovery after the exercise. Therefore, the exercise training with LBL may be one of the useful programs for improvement in physical performance and weight control for Thai women.

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Potential conflicts of interest

None.

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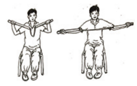
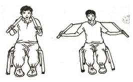
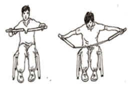
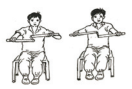
Appendix 1. Posture, movement, and description of exercise with Life-Build-Line

	Posture	Movement	Description of movements
1		Elbow flexion-extension	1. Both shoulders abduct 30 degree. 2. Both hands pull the LBL stretch with elbow flexion-extension. 3. Return to starting position.
2		Shoulder flexion-extension	1. The one arm takes the LBL stretch to an overhead position while the other arm stretches to shoulder extension. 2. Return to starting position and alternate both sides.
3		Shoulders abduct and Elbows flexion-extension	1. Move LBL to behind the head. Both shoulders abduct 90 degrees and elbows flex-extend. 2. Both hands pull the LBL stretch with elbow flexion-extension. 3. Return to starting position.
4		Flex trunk, elbow flexion- extension	1. Both shoulders abduct to 90 degrees. 2. Both hands pull the LBL stretch with elbow flexion-extension and trunk flexion. 3. Return to starting position.
5		LBL behind the head, elbow flexion-extension	1. Move LBL to behind the head. Both shoulders abduct to 90 degrees. 2. Both hands pull the LBL stretch with elbow flexion-extension. 3. Return to starting position.
6		LBL behind the head, elbow flexion-extension in the diagonal direction	1. Move LBL to behind the head. 2. Both hands pull the LBL stretch in the diagonal direction with elbow flexion-extension. 3. Return to starting position. Alternate on both sides.
7		LBL behind the head, elbow flexion-extension and rotation hands	1. Move LBL to behind the head. Both shoulders abduct to 90 degrees. 2. Both hands pull the LBL stretch with elbow flexion-extension. 3. Return to starting position.
8		LBL in front of the trunk, elbow flexion-extension	1. Move LBL in front of the trunk. Both shoulders abduct to 90 degrees or as tolerated. 2. One arm stretches the LBL in elbow flexion and another arm stretches the LBL in elbow extension. 3. Return to starting position.
9		LBL in front of the trunk, elbow flexion-extension in diagonal direction	1. Move LBL in front of the trunk. 2. Both hands pull the LBL stretch in the diagonal direction with elbow flexion-extension. 3. Return to starting position. Alternate on both sides.
10		LBL in front of the trunk, elbow flexion-extension in diagonal direction with flex hip-knee on one leg	1. Move LBL in front of the trunk. 2. Both hands pull the LBL stretch in the diagonal direction with elbow flexion-extension with flex hip and flex knee on one leg. 3. Alternate on both sides.
11		LBL behind the head, elbow flexion-extension with flex hip and flex knee on one leg	1. Move LBL to behind the head. Both shoulders abduct to 90 degrees. 2. Both hands pull the LBL stretch with elbow flexion-extension and flex hip and flex knee on one leg. 3. Alternate on both sides.
12		Rotate trunk, elbow flexion-extension in the diagonal direction	1. Rotate to the right (Rt) trunk with elbow extension and turn to starting position with elbow flexion. 2. Then rotate to the left (Lt) trunk with elbow extension and turn to starting position with elbow flexion.
13		Flex hip and flex knee with lateral trunk flex	1. Place both hands at LBL handles. 2. Pull LBL stretch with flex hip-knee at right (Rt) side with the lateral trunk flexing to the left (Lt) side. 3. Alternate to the other side.
14		Dorsiflexion and plantarflexion of both ankle joints	1. Pull LBL stretch with dorsiflexion and plantarflexion of both ankle joints. 2. Alternate to the other side.
15		External and internal rotation of both hip joints	1. Pull LBL stretch with external and internal rotation of one leg alternatively. 2. Alternate to the other side.

Appendix 1. (cont.)

	Posture	Movement	Description of movements
16		Both hip abduction	1. Pull LBL stretch with hip abduction.
17		Hip and knee extension	1. Pull LBL stretch with hip and knee extension. 2. Alternate to the other side.

ระดับความหนักและการใช้สารอาหารเป็นแหล่งพลังงานในหญิงสุขภาพปกติที่ไม่ออกกำลังกายเป็นประจำที่ออกกำลังกายด้วยอุปกรณ์สายสร้างชีวิต

ณิชานันทน์ ปัญญาเอก, ทวี ศิริวงศ์, คุรุศาสตร์ คนหาญ, อรทัย ตันกำเนิดไทย, พลอยไพลิน เอนกนันท์, นฤมล ลีลายุวัฒน์

ภูมิหลัง: *อุปกรณ์ออกกำลังกาย (สายสร้างชีวิต) เป็นอุปกรณ์การออกกำลังกายชนิดใหม่ที่ใช้สะดวกและไม่แพงมาก รวมทั้งรูปแบบของการเคลื่อนไหวทำให้อาจเป็นวิธีการหนึ่งที่ทำให้ประชาชนออกกำลังกายอย่างต่อเนื่องอันเป็นผลให้มีสุขภาพดีขึ้น อย่างไรก็ตามยังไม่มีการศึกษาที่พิสูจน์ระดับความหนักและผลของการออกกำลังกายด้วยอุปกรณ์นี้ต่อการใช้แหล่งพลังงานมาก่อน*

วัตถุประสงค์: *เพื่อประเมิน ระดับความหนักของการออกกำลังกายด้วยอุปกรณ์ออกกำลังกาย (สายสร้างชีวิต) ในหญิงสุขภาพปกติที่ไม่ออกกำลังกายเป็นประจำ และวัดการใช้แหล่งพลังงานระหว่างออกกำลังกาย วัตถุประสงค์แรกบ่งชี้ด้วยตัวบ่งชี้สัมบูรณ์ (การใช้พลังงาน) และตัวบ่งชี้สัมพัทธ์ (ร้อยละของการใช้ออกซิเจนสูงสุดและอัตราการเต้นของหัวใจสูงสุด ระดับของความเหนื่อยและความรู้สึกของการหายใจ) วัตถุประสงค์ที่สองบ่งชี้โดยการวัดค่าการใช้คาร์โบไฮเดรตและไขมันที่คำนวณจากการใช้ออกซิเจนและการผลิตคาร์บอนไดออกไซด์*

วัสดุและวิธีการ: *อาสาสมัครหญิงจำนวน 10 คน ออกกำลังกายโดยการสุ่มจำนวน 2 ครั้งๆ ละ 1 วัน ห่างกันอย่างน้อย 7 วัน เพื่อลดผลจากการออกกำลังกายครั้งแรก 1) ออกกำลังกายเพื่อหาค่าการใช้ออกซิเจนสูงสุด 2) ออกกำลังกายด้วยสายสร้างชีวิตที่มี 3 ช่วงๆ ละ 30 นาที ประกอบด้วย นอนพัก ออกกำลังกายด้วยสายสร้างชีวิต และพักฟื้นด้วยการนอนพัก การใช้ออกซิเจน การผลิตคาร์บอนไดออกไซด์ และการใช้พลังงาน จากอากาศที่หายใจออก ช่วง 5 นาทีสุดท้ายของการนอนพักและการออกกำลังกาย คลื่นไฟฟ้าหัวใจได้รับการบันทึกเพื่อหาอัตราการเต้นของหัวใจตลอดทั้งสามช่วง และอาสาสมัครถูกถามระดับความเหนื่อยและการหายใจทันทีที่สิ้นสุดการออกกำลังกาย*

ผลการศึกษา: *ระหว่างการออกกำลังกายด้วยสายสร้างชีวิต ค่าร้อยละของอัตราการใช้ออกซิเจนและอัตราการเต้นของหัวใจมีดังนี้ 43.5±2.32 และ 52.8±1.81 ของค่าสูงสุดตามลำดับ ในขณะที่การใช้พลังงาน ระดับความเหนื่อย และระดับการหายใจมีค่า 3.01±0.53 METs, 12.2±1.8 และ 3.0±1.41 ตามลำดับ นอกจากนี้การใช้ไขมัน โดยเฉพาะคาร์โบไฮเดรต เพิ่มขึ้นจากการออกกำลังกาย*

สรุป: *ผลการทดลองบ่งชี้ว่า การออกกำลังกายด้วยสายสร้างชีวิต มีความหนักของการออกกำลังกายเป็นระดับเบา และน่าจะทำให้เกิดประโยชน์ทางสรีรวิทยาและเมแทบอลิซึม*