

Turns in Jogging Increase Energy Expenditure: Proposed Home Exercise for Sedentary People

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Abstract

Introduction: We need to reevaluate exercise habits and exercise intensity in order to improve our health. We examined a new exercise pattern termed “slow jogging with turns”, which incorporates turns as an extra load in addition to jogging. This study aim to estimate Mets to create a home-exercise protocol.

Subjects and Methods: Ten participants performed slow jogging with turns and treadmill jogging in random order. Slow jogging with turns was performed in six stages at distances of 2.0 to 5.0 m, and treadmill jogging was performed at the same velocities as that for slow jogging with turns. We measured oxygen consumption, heart rate, and rating of perceived exertion.

Results: Mets data of slow jogging with turns and treadmill jogging were analyzed using repeated measurement ANOVA with p-value <0.01. Mets during slow jogging with turns were 6.5 ± 0.7 to 10.8 ± 0.9 . Mets during slow jogging with turns were significantly higher than those during treadmill jogging at equivalent speeds ($p < 0.0001$). Distance of slow jogging with turns corresponding to Mets was calculated as follows: $SJT \text{ distance (m)} = (\text{target Mets} - 3.06) / 1.5$

Conclusion: Slow jogging with turns can increase exercise intensity effectively, and exercise intensity can be adjusted individually by changing jogging distance. This form of exercise can be performed, anytime, anywhere and when done at greater than moderate intensity, helps increase energy expenditure in daily life.

Keywords: Slow jogging; Turn; Home exercise

Abbreviations: EE: Energy expenditure; HR: Heart rate; La: Lactic acid; Met: Metabolic equivalent; RPE: Rating of perceived exertion; SJT: Slow jogging with turns; TJ: Treadmill jogging; VO₂: Oxygen consumption.

Introduction

The World Health Organization (WHO) ranked lack of physical activity as the fourth leading cause of mortality worldwide [1]. Increased amount of daily physical activity decreases risk of morbidity and death due to life style related diseases such as cardiovascular disease, diabetes and cancer [2]. Additionally, in older people, it is possible to reduce the risk of deterioration of vital life functions and to expend their length of independent living [2]. Although knowledge about the effects of physical activity and exercise on health is already widespread among many people, the proportion of the population who habitually exercise is small and the amount of physical activity performed during leisure time is decreasing [3,4]. Many people have little “moderate” or “vigorous” physical activities [5].

Based on these current circumstances, “Global recommendations on physical activity for health” were presented. These guidelines recommended “moderate” to “vigorous” physical activities for each age

group. Because the amount and frequency of moderate or greater levels of physical activity in many people is decreasing, we need to reevaluate exercise habits and exercise intensity.

Continually upholding the habit of performing a high amount of physical activity for an extended period is difficult. The continuation rate of exercise has been shown to be low due to various reasons such as employment and the natural environment. Dishman [6] reported that approximately half of people discontinue physical activity and exercise within 3-6 months of starting.

Physical activity that is simple and easy to continue above moderate intensity is beneficial for health. Walking and running are representative kinds of aerobic exercise. They are generally recommended because they are basic, and can be performed anytime and anywhere, at one’s own pace without special skills. However, due to its low intensity, regular walking is not effective enough to lose weight and reduce some risk factors such as metabolic syndrome and cardiovascular disease [7,8]. Therefore, running is preferable to obtain sufficient effect.

Many people consider running to be too difficult and do not even attempt to try. One reasons for this problem is that the intensity of running does not match their physical fitness levels. The speed of natural transition from walking to running (preferred transition speed) is 6.5-7.9 km/h [9,10]. Assuming that the general speed of running is

8.0 km/h, its intensity is 8.6 Mets [11]. VO₂ max (25th-75th percentile) among those in their 50s is 7.6-9.7 Mets in women, and 9.2-11.9 Mets in men, thus running at a normal speed constitutes vigorous activity for many people.

Jogging at walking speed or even more slowly (slow jogging) is as easy as walking and can be performed safely. As reported previously, one's energy expenditure (EE) during jogging is significantly higher compared with walking at a speed of 6 km/h or less [12]. One's EE during jogging at 3-5 km/h is 1.7 times higher than that for walking at the same speed [12]. Furthermore, no difference exists in perceived exertion for walking and jogging at the same speed despite their EEs being significantly different [12]. Thus, slow jogging is easier to perform for many people because of its moderate or higher intensity and low fatigue rate; it can also have positive health effects [13].

Hatamoto et al. [14] showed that turning during sports required deceleration and acceleration and thus increased one's EE. The magnitude of the increase depended on both the turn frequency and running velocity. Because it was assumed that incorporating turns to slow jogging would be an additional load and that jogging intensity would increase significantly, we examined a new approach termed "Slow Jogging with Turns (SJT)". Not only the elderly but also children, healthy young people, and office workers are having problems resulting from lack of physical activity. In particular, many sedentary workers do not have exercise habits [4], and the lack of physical activity is a serious problem even for healthy people. If SJT constitutes easy and moderate or vigorous home exercises, it would prove useful for many people.

Not many aerobic exercises can be done in a small indoor area. Basic gymnastics and yoga have low exercise intensity, and exercise of high intensity generally require equipment such as a treadmill ergometer, cycle ergometer, or stepper. The benefits of adding turns to jogging (i.e., SJT) are not only that it increases one's EE, but it provides the possibility of exercising even in a small indoor area. Therefore, it is possible to minimize the influence of natural or life environment factors that may hinder exercise habits. Long TV viewing times, sedentary lifestyles, and low physical fitness are known to be related to obesity and metabolic syndrome. Hassapidou et al. [15] reported that the percentage of the population who spend a long time watching TV is high, while that who exercise is low. By effectively using one's TV viewing time to exercise instead, it is possible to make time for exercise without additional effort and to encourage people to habitualize exercise.

The purpose of this study is to confirm the physiological load of multistage SJT for healthy subjects and to create a home-exercise protocol.

Subjects and Methods

Ten men volunteered to participate in this study. All the subjects were physically active university students (mean age: 22.1 (standard deviation (SD) 5.0) years, height: 1.69 (SD 0.07) m, body mass: 61.6 (SD 6.7) kg, and peak oxygen consumption (peak VO₂): 56.5 (SD 5.8) mL/kg/minute). Individuals with back or lower limb pain, any musculoskeletal or neurological condition or vestibular impairment were excluded from participation.

The study was conducted between November and December 2015. All experiments were conducted in an indoor facility with polyvinyl chloride flooring at Fukuoka University Institute for Physical Activity, and the temperature during the experiments ranged between

22°C-24°C. All participants performed aerobic capacity test, and were assessed the EE of SJT and TJ a week later. All participants were instructed to sleep for at least 6 hours' before the test days, to avoid food, caffeine, tobacco products, and alcohol 3 hours prior to the trials, and to wear the same indoor sports shoes for each trial. Participants' EE during aerobic capacity test and both exercise tests was measured by collecting an expired gas sample through a facemask. Respiratory gas analysis was conducted using the mixing chamber method to evaluate the volume of expired air, and the O₂ and CO₂ fractions were analyzed by mass spectrometry (ARCO 2000, ARCO System, Chiba, Japan) every 12 seconds and averaged to 1 min. At the beginning of each trial, the system was calibrated using a 3-L calibration syringe for volume calibration, and the gas analyzers were calibrated using two different gas mixtures of known concentrations (20.93% O₂ and 0.04% CO₂; 15.00% O₂ and 4.55% CO₂).

The Ethical Committee of Fukuoka University, Fukuoka, Japan (number 10-02-0₂) approved the study, and informed consent was obtained from all participants. We followed the guidelines of the World Medical Association Declaration of Helsinki: Ethical Principles for Medical Research Involving Human Subjects, as well as the Ethical Guidelines for Epidemiological Research outlined by the Ministry of Education, Culture, Sports, Science and Technology and the Ministry of Health, Labour, and Welfare, Japan.

Aerobic capacity test

VO₂ max was measured using the athlete-led protocol for cardiopulmonary exercise test using a treadmill [16]. Participants started exercising at an easy running speed (8-10 km·h⁻¹) with no incline. The initial speed was set according to individual fitness level, and was increased by 1 km·h⁻¹ every 1 minute until participants reached a comfortable pace that they could maintain for the duration of the test. Once a comfortable running pace was found, the treadmill's incline was increased by a 1% gradient every minute until voluntary exhaustion. Each participant was encouraged to exert maximal effort. The test was stopped when participants could no longer maintain the set pace or had reached voluntary exhaustion. VO₂ values were recorded continuously throughout the trial. Expired gas was analyzed by mass spectrometry (ARCO 2000, ARCO System, Chiba, Japan). The average VO₂ during the last minute of jogging was regarded as the VO₂ peak. We also measured participants' heart rate (HR) during the last 30 seconds of jogging, rating of perceived exertion (RPE) using the Borg scale [17] immediately after the test and Lactic acid (La) value 1 min after test completion. VO₂ max was assumed to be reached when the oxygen uptake plateaued or three of the following five criteria were achieved: 1) at least 8 mmol/L of La concentration was reached; 2) age-adjusted 90% of maximal HR was reached; 3) at least 18 on the RPE scale was reached; 4) a respiratory exchange ratio greater than 1.10 was reached or 5) slope of the regression line of VO₂ in the last 1 minute of jogging was less than half. All participants fulfilled three or more of these five criteria.

Slow jogging with turns

SJT was defined as: 1) participants jogged back and forth at a given distance; 2) turn frequency was 20 times per minute; 3) jogging cadence was 180 steps per minute with six steps allotted per given distance during the jogging phase and three steps per turn phase. The jogging velocity varied depending on the distance.

Experimental Protocol for Assessing the EE of the SJT

Each subject performed six trials of SJT and treadmill jogging (TJ) in random order. SJT was performed at distances: 2.0, 2.5, 3.0, 3.5, 4.0 and 5.0 m, which corresponded to 2.4, 3.0, 3.6, 4.2, 4.8, and 6.0 km/h. TJ was performed at six velocities: 2.4, 3.0, 3.6, 4.2, 4.8, and 6.0 km/h, and the same as velocities for SJT were performed. The turning phase in SJT consisted of three steps, a deceleration step, a change of direction step, and an acceleration step at the end of the turn. SJT was performed using the cross-step turn technique, in which the runner turns away from the side of the supporting leg. All participants completed a familiarization session prior to the actual trial session, and before each trial, participants were reminded how to perform the SJT and practiced the turning technique for a few minutes. Cadence was not controlled for TJ so as to reproduce the same conditions as usual jogging. SJT and TJ sessions were performed at least 3 days apart.

The trial protocol is shown in Figure 1. Each trial consisted of six stages. Each stage lasted 4 minutes, with a 1-minute rest between stages. Step cadence during SJT was controlled using rhythmical music with beats. When participants could not maintain the cadence, the trials were stopped and restarted.

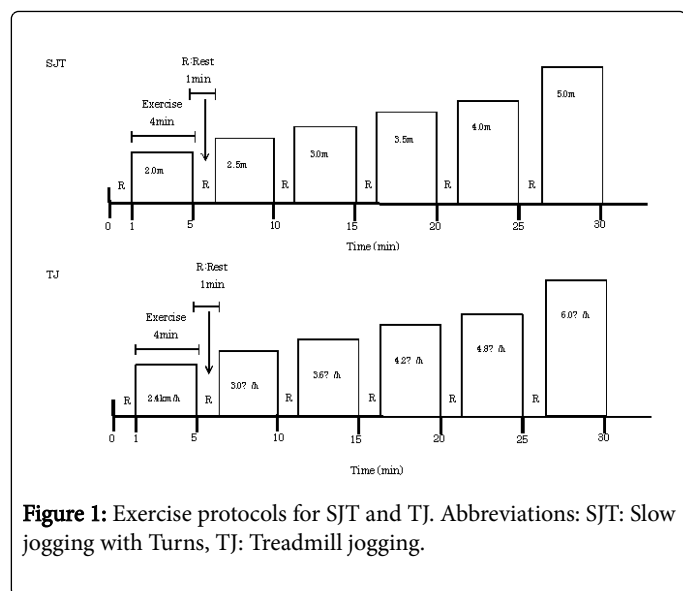


Figure 1: Exercise protocols for SJT and TJ. Abbreviations: SJT: Slow jogging with Turns, TJ: Treadmill jogging.

Gas exchange measurements were obtained during the trials (ARCO 2000, ARCO System, Chiba, Japan). VO_2 was assessed during the final 1 minute of each stage of the trial. HR was measured during the last 30 seconds using a Polar heart rate monitor (CE0537, Polar Electro, Kempele, Finland). After completing each stage, participants were asked to report their RPE.

Statistical Analyses

All analyses were conducted using SPSS software version 23 (SPSS, IBM, Armonk, NY, USA). All values are expressed as mean \pm standard deviation (SD). To investigate the influence of exercise type on exercise intensity, Mets data of TJ and SJT were analyzed using repeated measurement ANOVA and multiple comparisons were done using the Bonferroni test. Differences were considered significant at an alpha level of $p < 0.01$.

Results

All participants successfully completed all trials. Figure 2 shows changes in VO_2 every 1 minute, during each exercise. The VO_2 of the last 1 minute in all stages reached a steady state. Results of Mets, RPE and HR of SJT and TJ were shown in Table 1. The impact of SJT and TJ on exercise intensity was significantly different ($p < 0.0001$). The regression equation was calculated from the relationship between Mets and SJT distance, and the distance corresponding to Mets was calculated as follows: $SJT \text{ distance (m)} = (\text{target Mets} - 3) / 1.5$.

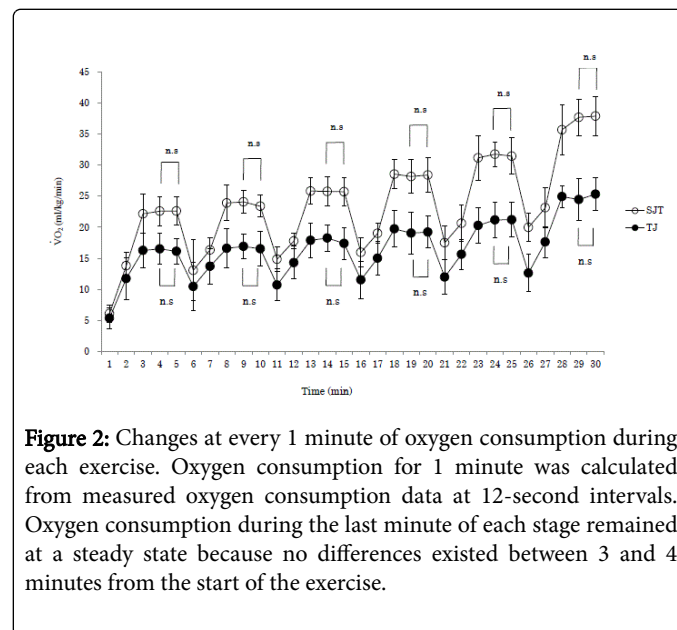


Figure 2: Changes at every 1 minute of oxygen consumption during each exercise. Oxygen consumption for 1 minute was calculated from measured oxygen consumption data at 12-second intervals. Oxygen consumption during the last minute of each stage remained at a steady state because no differences existed between 3 and 4 minutes from the start of the exercise.

| TJ | 2.4Km/h | 3.0Km/h | 3.6Km/h | 4.2Km/h | 4.8Km/h | 6Km/h |
|---|----------------|----------------|----------------|----------------|----------------|-----------------|
| Mets | 4.6 \pm 0.6 | 4.7 \pm 0.8 | 5.0 \pm 0.8 | 5.6 \pm 0.7 | 6.1 \pm 0.8 | 7.2 \pm 0.8 |
| RPE | 8.2 \pm 0.2 | 8.8 \pm 1.9 | 9.9 \pm 2.1 | 10.2 \pm 2.0 | 10.9 \pm 1.5 | 12.2 \pm 1.5 |
| HR | 101 \pm 17 | 101 \pm 14 | 104 \pm 14 | 108 \pm 15 | 111 \pm 12 | 121 \pm 16 |
| SJT | 2.0m | 2.5m | 3m | 3.5m | 4m | 5m |
| Mets | 6.5 \pm 0.7* | 6.7 \pm 0.5* | 7.4 \pm 0.7* | 8.1 \pm 0.8* | 9.0 \pm 0.8* | 10.8 \pm 0.9* |
| RPE | 9.3 \pm 2.3 | 10.2 \pm 2.3 | 10.7 \pm 2.1 | 11.7 \pm 1.9 | 12.7 \pm 2.1 | 14.21 \pm 2.1 |
| HR | 104 \pm 10 | 109 \pm 15 | 117 \pm 14 | 129 \pm 17 | 140 \pm 20 | 154 \pm 21 |
| * $p < 0.0001$ | | | | | | |
| * $p < 0.0001$ indicates that the Mets of SJT were significantly higher than that for TJ at same velocity. HR: heart rate, RPE: rating of perceived exertion, SJT: slow jogging with turns, TJ: treadmill jogging | | | | | | |

Table 1: Mets, RPE and HR during SJT and TJ.

Discussion

We found that SJT significantly increases exercise intensity if 20 turns per minute is added to slow jogging. The intensity of SJT is 1.4-1.5 times higher compared with that for TJ at the same velocity. In other words, the EE of turns in SJT corresponds to 40%-50% of total

EE of slow jogging (TJ), additional turns was shown to be effective for EE increase. Usually, to increase the exercise intensity of running, one increase their running velocity, but we show that adding turns can meet the same goal even if running velocity is maintained or slowed down. Thus, reaching one's target exercise intensity can be easily obtained without increasing one's running velocity. Further, results show that exercise of up to 10 Mets can be achieved despite being small indoor area; this intensity is similar to that of competitive sports [18]. SJT may help not only improve sedentary lifestyle by increasing the amount of one's physical activity, but also improves physical fitness because it can cope with a wide range of fitness levels.

Exercise has been demonstrated to be effective on almost all aspects of humans, ranging from cardiorespiratory function to cognition, and aging [19]. However, there is a threshold below which physical activity does not confer increase in aerobic capacity and muscle strength, or protection against metabolic syndrome [7,8,20]. Usual walking is not effective enough to increase aerobic capacity and muscle strength, contribute to weight loss, and reduce some risk factors, because of its low-intensity. In a recent study, high-intensity interval walking training was effective in increasing aerobic capacity and muscle strength of knee [20] and improving hyperglycemia, hypertension and obesity [21]. Walking with increased speed brings some effects that are absent in usual walk. However, brisk walk increases pressure in areas such as anterior tibialis muscle and hamstrings [10], and slow jogging is associated with lower RPE even for the same exercise intensity [12]. Because SJT is easy to do, there is a possibility that it may be an alternative exercise to brisk walk. It is recommended that daily physical activities include not only moderate intensity but also vigorous intensity [22]. Especially for children and adults who lack physical activity, vigorous exercise such as SJT is necessary. Furthermore, vigorous intensity exercise is effective to increase daily EE by taking advantage of short time such as during housework or one's work break times.

SJT that leads to high-calorie expenditure may also be an effective obesity treatment. The obese and overweight population is currently increasing globally [23]; the cause of weight gain is not only an increase in energy intake but also a significant decrease in EE resulting from a sedentary lifestyle and lack of sports activity [24,25]. Treatment for obesity includes weight loss by dietary calorie restriction and increased physical activity, which reduces the risk of many medical complications related to obesity [26]. Weight loss prevents type II diabetes [27] and improves insulin sensitivity [28,29], clotting parameters [30], lipid values [31,32], fasting glucose levels [32], blood pressure [32,33], and systemic inflammation [34]. To lose weight, achieving a negative energy balance is necessary [28]. Easy aerobic exercise that leads to high-calorie expenditure is particularly recommended for obese and overweight people [35-37]. Walking is often prescribed as exercise therapy for obesity. The intensity of regular walking (4.2 km/h) is 3 Mets [11]. At the same velocity, intensity was 5.6 Mets for TJ and 8.1 Mets for SJT in this study. Thus, EE will be 1.9 times more for TJ and 2.7 times more for SJT than for walking, and thus SJT can effectively increase EE.

To create a SJT protocol, the SJT distance corresponding to Mets was calculated. Table 2 shows SJT distances corresponding to 5 to 10 Mets. Effective exercise is possible by prolonging distance according to physical fitness improvement. SJT may be difficult for frail older people because of its high intensity, but can be performed easily by many people including healthy elderly. By dividing the turn phase into 3 steps, it is possible to disperse the momentum necessary for turns and

to reduce the stress of each step. Since the body rotation angle per one step also becomes smaller, the torsional moment applied to the femoral tibia joint decreases, and the stress on the joint structure is likely to decrease. SJT didn't empirically increase pain in the elderly we work with. For low-fitness individuals, we recommend starting with adding turns to walks instead of slow jogging (Slow Walking with Turns: SWT). We have already shown that even slow walking becomes moderately intense only by adding turns [38]. SJT and SWT can be performed in a small area such as a room for a wide range of physical fitness levels, and because exercise intensity has been quantified, it can be adjusted according to one's physical fitness without equipment such as a treadmill ergometer. SJT can be suggested as a useful exercise not only to increase the amount of physical activity that sedentary people perform and to lose weight for obese people but also to increase physical fitness for athletes.

| Target-Mets | SJT-distance (m) |
|------------------------------|------------------|
| 5 | 1.3 |
| 6 | 2 |
| 7 | 2.6 |
| 8 | 3.3 |
| 9 | 4 |
| 10 | 4.7 |
| SJT: slow jogging with turns | |

Table 2: Distance achieved when performing SJT according to target Mets.

In this study, we compared SJT on the floor with TJ at the same speed. Both approaches have different floor conditions. While Ralston [39] reports that TJ and floor walking are metabolically the same, no consensus exists with regard to whether the results from treadmill walking accurately represent overground walking. Some studies reported that walking on a treadmill versus a floor differ kinematically [40] and metabolically [41,42]. The current study is a comparison between SJT and TJ with different floor conditions, and TJ may not be synonymous with jogging on the floor (slow jogging). One's EE during SJT may include not only surplus EE due to additional turns but also EE due to differences in floor conditions.

The limitation of the present study is that the subjects are limited to healthy individuals. In this study, no remarkable increase in HR and RPE or other reason to stop exercise was observed. To secure safety of SJT, we need to extend the subjects to patients and to confirm long-term effects in the future.

In conclusion, SJT that incorporates turning as an extra load additional to jogging can increase exercise intensity effectively, and exercise intensity can be adjusted individually by changing the jogging distance. Because SJT can be performed in a small indoor area by incorporating turns, exercise is not affected by factors induced by the natural environment such as summer heat, cold in winter or rain, and exercise can be performed comfortably. Furthermore, SJT allows one to effectively use their time because it can be performed while carrying out other activities, such as when doing housework, during one's work break times and when watching TV. Therefore, it is possible to make time for exercise without additional effort and to encourage people to habitualize exercise. SJT, which can be performed anytime and

anywhere with more than moderate intensity, will help increase EE in daily life. Lack of physical activity is an issue worldwide. We would like to propose SJT as a type of exercise that can be easily performed by most people who are not interested in physical activity and sports.

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