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The effect of treadmill-based and track-based walking training on physical fitness in ankle-sprain experienced young people

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The purpose of this study was to evaluate the effects of 12-week treadmill-based (MT) and track-based (TT) walking program on maximal oxygen consumption (VO_{2max}), muscular endurance, muscle strength, and ankle range of motion (ROM) in ankle sprain experienced young people. Twenty subjects (12 males, 8 females) volunteered to participate in this study and divided into two groups (MT and TT). All subjects completed MT and TT 4 times per week with each session of 60 min with 65% from maximum heart rate. Incremental test on treadmill and 20-m shuttle run test for endurance capacity (VO_{2max}), 2-km walking test for muscular endurance, vertical jump for strength, and ankle ROM for flexibility were analyzed before and after the training intervention. We found significant increase in incremental, 2-km walking and 20-m shuttle run after both MT and TT. Just after TT were significant increased vertical jump and ankle ROM. In conclusion, TT seems to induce a more positive effect on muscle strength in lower extremity and ankle ROM than treadmill-based walking training in ankle sprain experienced young people.

Keywords: Treadmill walking, Track walking, Ankle ROM, Ankle sprain, Strength

INTRODUCTION

Walking has been widely used in gait study and associated with decreased risks of cardiovascular disease (Hamer and Chida, 2008; Kelly et al., 2014), falls, and all-cause mortality (Hausdorff et al., 2001). The treadmill is advantageous instrument to be accepted as a useful physical and clinical assessment for people and patients with ankle sprain (Schache et al., 2001). Recently, a new generation of instrumented treadmills has been developed for various studies in sports physiology. However, similarly or different training effects between treadmill and overground have been still controversial area (Alton et al., 1998; Nelson et al., 1972; Nigg et al., 1995).

Concerning kinematics, studies shows inconsistent evidence on whether treadmill (TW) and overground walking (OW) are identical and compare TW and OW. Elliot and Blanksby (1976) reported that treadmill runners decreased their stride length, which resulted in an increased stride rate and decreased time in wing. Another study reported that treadmill runners have decreased ankle dorsiflexion at heel strike compared to their overground stride (Nigg et al., 1995) and the treadmill preferred speed was on average 17.2% slower than the corresponding overground preferred speed among healthy, young individuals (Dal et al., 2010).

Schache et al. (2001) demonstrated similar lumbo-pelvic-hip complex three dimensional kinematics in treadmill and overground running and Frishberg (1983) reported that sprint kinematics in five collegiate level sprinters overground and on a treadmill is compared and found no significant differences in stride frequency, step length, support time, or flight time between the two groups. Moreover, Riley et al. (2008) concluded that overground and treadmill kinetic variables were similar enough to utilize treadmill-based research protocols for the study of overground running gait despite statistically significant kinematic and kinetic differences which were not felt to be clinically important.

Although similarly or different evidence between study of

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treadmill and overground running have been demonstrated, to our knowledge, there were various training effects on muscle strength, recovery of muscle fatigue, angle of ankle between treadmill training and overground training. This various training effects are very important to demonstrate because gait training is the most common therapeutic intervention currently used to improve physical activity. Therefore, we examined the effects of 12-week treadmill-based training (MT) and track-based training (TT) on VO_{2max}, muscular endurance, muscle strength and ankle ROM.

MATERIALS AND METHODS

Subjects

Twenty subjects (12 males, 8 females) volunteered to participate in this study (Table 1). Subjects were moderately trained students and they had experience of ankle sprain at least 1 time in 1 year. They had previously been screened and diagnosed by an orthopedic surgeon. Any subjects did not present any neurological signs of pathological importance in the clinical examination. Prior to the study, participants were informed about the purpose, procedures and risks of the study and written informed consent was obtained from each participant.

Experimental design

The subjects were divided into two groups. This study was a controlled trial where the effects of two different track-based (MT, n = 10) and treadmill-based training programs (TT, n = 10) were compared to each other.

Exercise program

The subjects completed 12 weeks supervised walking training program. The training was done 4 times a week: 3 times per week (Monday, Wednesday, and Friday) under supervision on track and treadmill and 1 time per week (Saturday) without supervision. On the track and treadmill subjects performed walking training for 60 min at the work load corresponding to 65% of the maximum heart rate.

Incremental treadmill testing

Subjects performed incremental treadmill testing until volitional exhaustion to determine VO_{2max} and the intensity associated with the achievement of VO_{2max}. This test started with worming up at 1.6 m/sec for 5 min and after worming up, speed was increased of 0.4 m/sec at each stage. The test completion was determined by volitional exhaustion and after the test (1 min and 3 min), heart rate was measured with Polar Pacer (Polar Electro Oy, Kempele, Finland).

Table 1. Physical characteristics of subjects

Characteristic	Male (n = 12)	Female (n = 8)
Age (yr)	22	21
High (cm)	175.3 ± 6.88	162.9 ± 2.4
Weight (kg)	75.8 ± 11.00	58.4 ± 6.7

Values are presented as mean ± standard deviation.

20-m shuttle run test

All subjects ran in a straight line between two lines 20 m apart, while keeping pace with prerecorded audio signals. The initial speed was 8.5 km/hr and increased by 0.5 km/hr per minute. The test was finished when the participant failed to reach the end lines keeping pace with the audio signals on two consecutive occasions or when the subject stopped because of fatigue.

2-km walking test procedure

Each subject walked a 2-km distance. The walks took place on a 400-m outdoor-track. The temperature during the test was between 21°C–24°C, and humidity was between 55%–60%. All subjects stared individually every 1 min. the instruction for the walks was: "walk the distance as fast as you can." Walking time was recorded on the finish line. Immediately after the walk test (1 min and 3 min), heart rate was measured with Polar Pacer.

Ankle ROM

Subjects lay supine with outstretched legs on an examination table without any pad, cushion or pillow underneath. The testing position of ankle started 90° and the ROM of the ankle was calculated by the summation of degrees of plantar flexion and dorsi flexion. The greater degree means the higher flexibility.

Jumping test

The vertical jump was measured via Helmas III (O2-Run, Seoul, Korea). All subjects was instructed to perform a vertical jump as fast as and as high as they could. The highest of the three attempts was recorded for peak power. Participants received 1-min pause between vertical jump attempts.

Statistical analysis

Data is presented as mean values with standard deviation. A paired *t*-test was used to evaluate differences before and after training. IBM SPSS Statistics ver. 22.0 (IBM Co., Armonk, NY, USA)

Table 2. The change of fitness test after 12-week walking training on treadmill

Test item	Pre	Post	*t*	*P*-value
VO_{2max}				
Incremental (m/sec)	3.8±0.5	4.2±0.3	-3.498	0.007*
20-m shuttle run (whole-level)	64.8±19.6	73.4±19.3	-4.027	0.003*
Muscular endurance				
2-km walking (sec)	1001.2±62.9	908.4±74.8	4.601	0.001*
Strength				
Vertical jump (cm)	45.9±9.6	47.9±9.4	-2.524	0.058
Flexibility				
Ankle ROM (Δ°)				
Right	70.1±13.6	68.7±11.5	0.264	0.798
Left	70.3±18.0	68.0±10.9	0.491	0.635

Values are presented as mean±standard deviation.
Pre, before training; Post, after training; VO_{2max}, maximal oxygen consumption; ROM, range of motion.
*$P<0.05$, statistically significant difference.

Table 3. The change of fitness test after 12 weeks walking training on track

Test item	Pre	Post	*t*	*P*-value
VO_{2max}				
Incremental (m/sec)	4.0±0.4	4.2±0.6	-2.449	0.037*
20-m shuttle run (whole-level)	988.5±73.7	899.8±83.8	7.465	0.000*
Muscular endurance				
2-km walking (sec)	64.6±19.6	73.7±19.0	-6.002	0.000*
Strength				
Vertical jump (cm)	42.0±11.9	45.6±12.8	-3.632	0.005*
Flexibility				
Ankle ROM (Δ°)				
Right	86.4±16.4	90.7±12.2	1.060	0.017*
Left	80.2±9.6	87.5±8.4	-2.071	0.048*

Values are presented as mean±standard deviation.
Pre, before training; Post, after training; VO_{2max}, maximal oxygen consumption; ROM, range of motion.
*$P<0.05$, statistically significant difference.

was used for all analyses, and a *P*-value of 0.05 was set for significance.

RESULTS

Incremental test (VO_{2max})

The incremental test was significantly increased of maximum speed after both MT (from 3.8±0.5 to 4.2±0.3 m/sec) and TT (from 4.0±0.4 to 4.2±0.6 m/sec) (Tables 2, 3).

2-km walking test

After 12-week program, speed were significantly increased from 1,001.2±62.9 to 908.4±74.8 sec after MT and 988.5±73.7 to 899.8±83.8 sec after TT respectively (Tables 2, 3).

20-m shuttle run test

The 20-m shuttle run test was significantly increase of maximum level after both MT (from 64.8±19.6 to 73.4±19.3 level) and TT (from 64.6±19.6 to 73.7±19.0 level) (Tables 2, 3).

Vertical jump test

The vertical jump increased significantly only after TT (from 42.0±11.9 to 45.6±12.8 cm) and remained unchanged after MT (from 45.9±9.6 to 47.9±9.4 cm) (Tables 2, 3).

ROM of ankle

The ROM of both right and left ankle increased significantly only after TT (right: from 86.4°±16.4° to 90.7°±12.2° and left: 80.2°±9.6° to 87.5°±8.4°) and remained unchanged after MT

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(right: from 70.1°±13.6° to 68.7°±11.5° and left: 70.3°±18.0° to 68.0°±10.9°) (Tables 2, 3).

DISCUSSION

The aim of present study was to determinate effects of treadmill-based (MT) and track-based training (TT) for VO_{2max}, muscular endurance, muscle strength and ankle ROM.

The main findings of this study were founded significantly positive effects on VO_{2max} and muscular endurance both after MT and TT. Especially, vertical jump (strength) and ankle ROM (flexibility) increased significantly just after TT.

Numerous studies have compared effects of TW and OW, however, there exists still conflict results between both training methods. Several studies have reported that significant differences of higher energy cost in track running than on the treadmill were observed because of air resistance during track training (Jones and Doust, 1996; Van Ingen Schenau, 1980) and a better running economy on the track training in higher maximal velocities and longer exercise durations being sustained (Meyer et al., 2003). On the other hand, contradictory results showing there is not significantly different effects or impairment of locomotion between track and treadmill (Bassett et al., 1985; Jones and Doust, 1996; McMiken and Daniels, 1976; Pugh, 1970) and the respiratory exchange ratio did not differ between TW and OW (Kong et al., 2012). As a result of the present study, 12-week treadmill-based (MT) and track-based walking training (TT) showed positive effects such as increases of VO_{2max} and muscular endurance. Many other studies have demonstrated that walking exercise positive influence on aerobic capacity and the association between walking and the risk of all-cause mortality may be partly due to reduced risk of cardio vascular disease (Hamer and Chida, 2008). Especially, our study found effect of strength (vertical jump) and flexibility (ankle ROM) after MT and TT. These results are important point because walking is usually used overall rehabilitation-stage for lower extremity. These patients need improved muscle strength and movable joint as possible for normal gait. Therefore walking method with treadmill or track training can be important for starting and process of rehabilitation. Several studies supported these results that the ankle was less dorsiflexed at foot strike (Nigg et al., 1995; Wank et al., 1998) and Riley al. (2007) found a decreased stride length during treadmill running. This evidence matched with our result. The significant increase of strength and ankle ROM just after TT was observed and this two results are the important body part for the strategy of keeping balance and avoiding falling for starting of rehabilitation, all patients (Winter, 1995) and especially, for ankle sprain experienced patients.

In conclusion, this study demonstrated that track-based walking induced a more muscle strength in lower extremity and ankle ROM than treadmill-based training in ankle sprain experienced young people. Further researches are needed to verify current results with various generations and with numerous people.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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