Medicina Sportiva (2012), vol VIII, no 1, 1743 - 1749
Romanian Sports Medicine Society

An empirical study of backward walking treadmill training on static and dynamic balance in adolescent girls

Baljinder Singh Bal[1], Gaurav Dureja[2], Parminderjeet Kaur[3]
[1]*Guru Nanak Dev University, Amritsar, India*
[2]*Post Graduate Government College, Sector-11, Chandigarh (U.T.), India*
[3]*Baring Union Christian College, Batala, India*

Abstract. The purpose of this study was to investigate the effect of backward walking treadmill training on static and dynamic balance. Forty adolescent girls (mean ± SD: age 15.55 ± 1.8 years, height 1.721± 0.00871 m, body mass 65.255 ± 0.468 kg), who participated in interschool volleyball competition and in the Catch Them Young (CTY) programme organised by Guru Nanak Dev University, Amritsar volunteered to participate. All participants were informed about the study aim and methodology as well as about the possibility of immediate acceptance at any time of the experimentation. Subjects agreed to the above conditions in writing. They were randomly assigned into two groups: A (Training Group) and B (Control Group), n=20 each. The subjects from training group were subjected to a 5-week treadmill training programme. This lasted 5-weeks and consisted of daily sessions, lasting 50 min each. The students completed the stork stand and wobble board tests to determine static balance on the leg respectively. The static and dynamic balance significantly improved in training group compared with the control one. The backward training may be recommended to improve static and dynamic balance and may contribute to enhance concentration based performance.
Key words: *walk, treadmill, static, dynamic*.

Introduction

Changing the direction of locomotion from normal forward progression to backward is done rather readily by all people. In order to change the direction from forward locomotion to backward, the pattern of muscle activation has to be changed to produce a reversal of leg movement and propulsion in backward direction. Walking backward means reversing leg movement trajectories. When walking backward, the leg not only reverses its direction of movement but it travels in the opposite direction along virtually the same path as in walking forward. Walking backward is nearly a mirror image or time-reversed copy of walking forward (1, 2). Winter, Plauck and Yang (3), in an investigation of similarities and differences in forward and backward walking, found that backward walking was 95% reversal of forward walking. In contrast, both Vilensky et al (4) and Kramer (5) concluded that backward walking was different from forward walking. They reported that walking backward was associated with increased cadence and decreased stride length when compared with forward walking. Walking and running in the backward direction are relatively novel tasks for most people but there are several situations in which these movements are performed regularly. Various sports such as soccer, football and basketball require the use of backward locomotion in a variety of situations. Backward locomotion is also commonly used in rehabilitation treatment as a modality for injuries such as patella femoral pain syndrome (6-10) or ligament injuries (11), and as a means of maintaining cardiopulmonary fitness (11,12) while limiting the amount of stress placed on injured structures. Walking backward has also been used for injury prevention, to increase muscle strength (13-16) and to facilitate neuromuscular function. Several studies have investigated backward walking and its effects while walking on the treadmill (17-20). The treadmill is frequently used in biomechanical studies for locomotion and training (19), as variables such as speed or slope can be controlled and as multiple gait cycles can be assessed easily (21).

The treadmill allows for a controlled environment and provides a standardized and reliable performance task, a convenient means of taking measurements from a walking subject without the necessity of having to physically follow the subject with the recording equipment; it is therefore often used for locomotion research (19, 22). Furthermore, treadmill training in forward walking has been administered for treating a number of conditions and benefits have been gained (4, 24, 25). This promoted us to undertake this study with the aim to determine the effect of backward walking treadmill training on static and dynamic balance.

Materials and Method

Samples. Forty adolescent girls (mean ± SD: age=15.55 ± 1.8 years, height=1.721± 0.00871 m, body mass=65.255 ± 0.468 kg), who participated in interschool volleyball competition and in the Catch Them Young (CTY) programme organised by Guru Nanak Dev University, Amritsar volunteered to participate. All participants were informed about the study aim and methodology as well as about the possibility of immediate acceptance at any time of the experimentation. Subjects agreed to the above conditions in writing. They were randomly assigned into two groups: A (Training Group) and B (Control Group), n=20 each.

Table I. Subjects' Demographics

Variable	**Group**	
	Training Group (N=20)	Control group (N=20)
	Mean ± SD	Mean ± SD
Age (years)	15.55 ± 1.73	15.55 ± 1.9
Body mass (kg)	65.235 ± 0.452	65.275 ± 0.494
Body height (m)	1.7215 ± 0.00933	1.7205 ± 0.00826

Methodology. The study was approved by the Ethics Committee of Directorate of Sport in Guru Nanak Dev University, Amritsar, India. The subjects from training group underwent backward walking treadmill training for 5 sessions a week for 5 weeks. In each session, 15 minutes of backward walking treadmill training (BWTT) was administered. In order to do the backward treadmill training, initially the subjects performed a warm-up session for 5 minutes by walking on the treadmill at a self-selected speed and then they were given a 1-minute rest before the training session started. In the training session, the subjects walked backward on the treadmill at the speed of 1.33 m/sec for 5 sessions/week for 5 weeks. Every working day, a net walking time of 20 min of backward walking treadmill training (BWTT) was done (figure 1).

The stork stand was used to measure balance. For the stork stand, the subjects completed the test on the dominant and non-dominant foot. The subjects kept their hands on their hips with the uninvolved foot against the medial side of the knee of the stance leg. Each subject maintained this position while standing on the ball of the foot for the maximum possible time. The trial ended when the heel of the involved leg touched the floor, the hands came off of the hips, or the opposite foot was removed from the stance leg. The best of three trials was recorded for analysis.

For the measurement of the dynamic balance, the subjects also performed the wobble board test in a unilateral stance on their dominant and non dominant foot. With the shoes off, the subjects stood on the center of the wobble board and the uninvolved foot free to move in space. During a 15 second period, each subject attempted to maintain balance without allowing the board to touch the contact plate that was positioned on the floor 2 inches under the wobble board. The subjects were instructed to regain their balance as quickly as possible when the wobble board touched the contact plate. Within the 15 second period, the duration the wobble board touched the contact plate (time off balance) was recorded for analysis. The least duration of time off balance during the 15 second period after 3 trials was analyzed.

Statistical analysis. Statistical®7.0 software was used in data analysis. Student's t-test for independent data was used to assess the between-group differences and for dependent data to assess the Post-Pre differences. The level of $p \leq 0.05$ was considered significant.

Figure 1. A. Backward walking , B. Static balance C. Dynamic balance

Results

The results of backward walking treadmill training on static and dynamic balance of the training and control groups are presented in the following table.

	Training Group	
	Pre-Test	Post-Test
Sample size	20	20
Arithmetic mean	35.6500	38.9000
95% CI for the mean	34.0056 to 37.2944	35.9365 to 41.8635
Variance	12.3447	40.0947
Standard deviation	3.5135	6.3320
Standard error of the mean	0.7856	1.4159
Mean difference		3.2500
Standard deviation		7.9132
95% CI		0.4535 to 6.9535
Test statistic t		1.837
Degrees of Freedom (DF)		19
Two-tailed probability		P = 0.0819
	Control Group	
	Pre-Test	**Post-Test**
Sample size	20	20
Arithmetic mean	25.6500	26.5500
95% CI for the mean	24.3152 to 26.9848	24.8764 to 28.2236
Variance	8.1342	12.7868
Standard deviation	2.8521	3.5759
Standard error of the mean	0.6377	0.7996
Mean difference		0.9000
Standard deviation		3.5378
95% CI		0.7557 to 2.5557
Test statistic t		1.138
Degrees of Freedom (DF)		19
Two-tailed probability		P = 0.2694

Table II. Static balance of training and control group paired samples t-test

Table II shows that the mean of static balance of pretest of training group and posttest of training group was 35.65 and 38.90 respectively, whereas the mean of static balance of pre test of control group and post test of control group was 25.65 and 26.55. The t value in case of experimental group was 1.837 and for control group it was 1.138. The critical value of t at 95% probability level in training group is much lower (1.72) than the observed value of t (1.837).

The data does suggest that the differences between pre-test and post test of static balance in training group are significant. The graphical representation of responses has been exhibited in figure 2.

	Training Group	
	Pre-Test	**Post-Test**
Sample size	20	20
Arithmetic mean	27.6500	30.4000
95% CI for the mean	26.0127 to 29.2873	28.0457 to 32.7543
Variance	12.2395	25.3053
Standard deviation	3.4985	5.0304
Standard error of the mean	0.7823	1.1248
Mean difference		2.7500
Standard deviation		6.5040
95% CI		0.2940 to 5.7940
Test statistic t		1.891
Degrees of Freedom (DF)		19
Two-tailed probability		P = 0.0740
	Control Group	
	Pre-Test	**Post-Test**
Sample size	20	20
Arithmetic mean	25.6500	26.7000
95% CI for the mean	24.3152 to 26.9848	25.3410 to 28.0590
Variance	8.1342	8.4316
Standard deviation	2.8521	2.9037
Standard error of the mean	0.6377	0.6493
Mean difference		1.0500
Standard deviation		3.3635
95% CI		0.5242 to 2.6242
Test statistic t		1.396
Degrees of Freedom (DF)		19
Two-tailed probability		P = 0.1788

Table III. Dynamic balance of training and control group paired samples t-test

Table III shows that the mean of dynamic balance of pretest of experimental group and posttest of experimental group was 27.65 and 30.40 respectively, whereas the mean of static balance of pre test of control and post test of control group was 25.65 and 26.70. The critical value of t at 95% probability level in training group is much lower (1.72) than the observed value of t (1.891). The data does suggest that the differences between pre-test and post test of dynamic balance in training group are significant. The graphical representation of responses has been exhibited in figure 3.

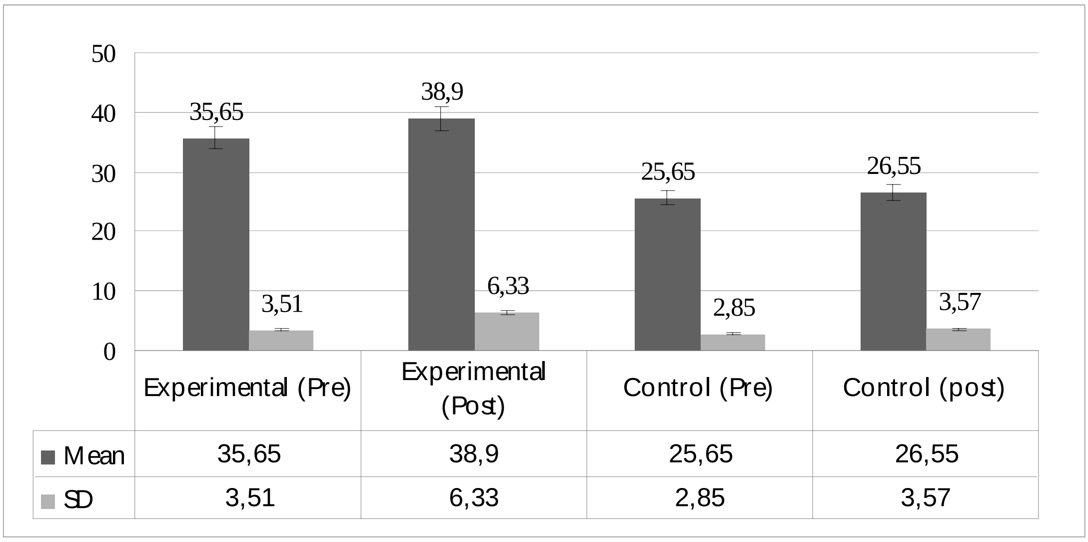

Figure 2. Mean, standard deviation (SD), standard error of mean (SEM) of balance of training and control group

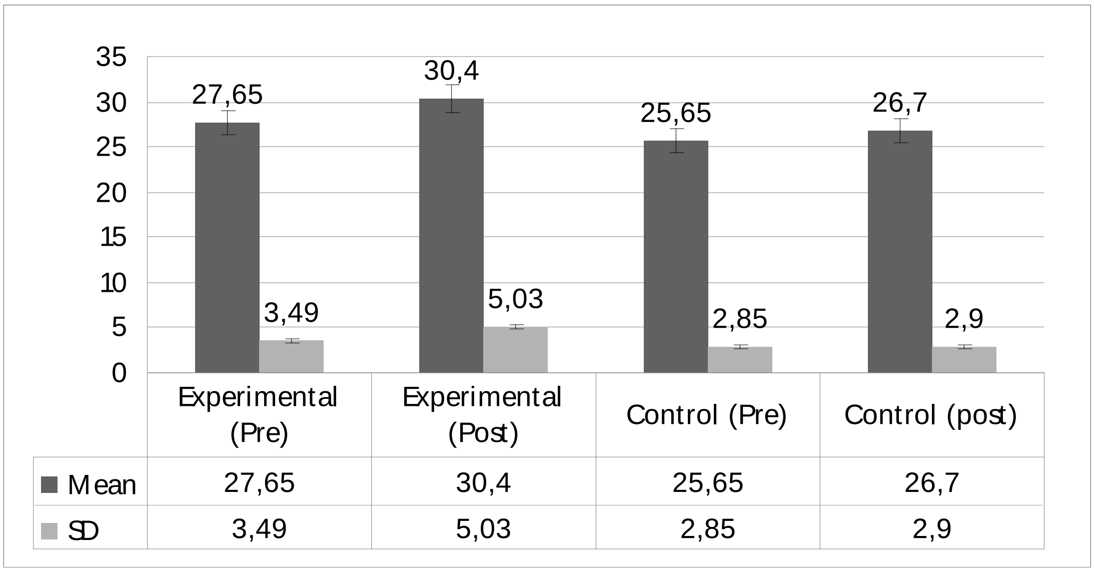

Figure 3. Mean, standard deviation (SD), standard error of mean (SEM) of dynamic balance of training and control group

Discussion

Walking and running in backward directions are relatively novel tasks for most people, whereas there are several situations in which these movements are performed regularly, such as in soccer, football and basketball (25). The present study analyzed the effect of backward walking treadmill training on static and dynamic balance. Backward walking treadmill training on the effect of backward walking treadmill training on static and dynamic balance**.** A previous study by Van Ingen Schenau (22) suggested that visual information is particularly important in maintaining equilibrium and stability during locomotion; while in over-ground locomotion the surroundings move with respect to the subject, this is not the case in treadmill walking. This implies that equilibrium and stability decrease on the treadmill causing a fear of falling, and resulting in the reduced gait speed. This reduction in speed causes a reduction in cadence and an increase in step length, which is a possible cause of an increase in the hip and knee angles. Thus such decreased equilibrium and stability showed an increase in kinematics for the hip and the knee before backward walking treadmill training and the decreased kinematics for the hip; the differences shown in the results after backward walking treadmill training could have been due to the habituation in all subjects to backward walking on the treadmill. A 15 minutes' period of familiarization was given to all subjects on the treadmill but, according to Wall and Charteris (26), a steady state cannot be achieved even after 10 minutes of treadmill walking. Wall and Charteris (27) investigated the process of habituation to the treadmill and showed stride-to-stride variations in walking even after 15 min on the treadmill.

Acknowledgements. Authors would like to thank department of Physical Education and Sports (AT) Guru Nanak Dev University, Amritsar (Punjab) for providing assistance in collecting the relevant information for undertaking quality research.

References

1. Andrea, N. L., Hass, C. J. and Gregor, R. J. (2007). The effects of sloped surfaces on locomotion: Backward walking as a perturbation. *J Biomech*. 40: 3050-3055.
2. Baker, P. A., Evans, O. M. and Lee, C. (1991). Treadmill gait retraining following fractured neck of femur. *Arch Phys Med Rehab*. 72: 649-652.
3. Winter, D. A., Plauck, N. and Yang, J. F. (1989). Backward walking a simple reversal of forward walking? *J Motor Behav*. 21: 291-305.
4. Vilensky, A. Gankiewicz, E., and Gehlsen, G. (1987). A kinematic comparison of backward and forward walking in humans. *Hum Mov Studies.*, 13: 29-50.
5. Kramer, P. G. (1980). Restoration of dorsiflexion after injuries to the distal leg and ankle. *J Orthop Sports Phys Ther.*, 1(3): 159-164.
6. Devita, P. and Stribling, J. (1991). Lower extremity joint kinetics and energetic during backward running. *Med Sci Sports Exerc*. 23(5): 602-610.
7. Flynn, T. W. and Soutar-Little, R. W. (1993). Mechanical power and muscle action during forward and backward running. *J Orthop Sports Phys Ther*., 17(2): 108-112.
8. Flynn, T. W. and Soutas-Little, R. W. (1995). Patella femoral joint compressive forces in forward and backward and running. *J Orthop Sports Phys Ther*., 21(5): 277- 282.
9. Flynn, T. W., Connery, S. M., Smutok, M. A., Zeballos, R. J. and Weisman, I. M. (1994). Comparison of cardiopulmonary responses to forward and backward walking and running. *Med Sci Sports Exerc*. 26(1): 89-94.
10. Grosso R., Bianchi. L. and Lacquaniti. F. (1998). Motor patterns of human gait: Backward versus forward locomotion. *J Neurophysiol*, 80: 1868-1885.
11. Hesse, S., Bertelt, C., Schaffrin, A., Malezic, M. and Mourtz, K-H. (1994). Restoration of gait in no ambulatory hemi paretic patient by treadmill training with partial body-weight support. *Arch Phys Med Rehab*. 75: 1087-1093.
12. Hooper, T. L., Dunn, D. M., Props, J. E., Bruce, B. A., Sawyer, S. F. and Daniel, J. A. (2004). The effects of graded forward and backward walking on heart rate and oxygen consumption. *J Orthop Sports Phys Ther*., 34: 65-71.
13. Hreljac, A., Imamura, R., Escamilla, R. F., Casebolt, J. and Sison, M. (2005). Preferred and energically optimal transition speeds during backward human locomotion. *J Sports Sci Med*., 4(4): 446-454.
14. Li, J. X. and Hong, Y. (2007). Kinematics and electromyographic analysis of trunk and lower limbs during walking in negative-heeled shoes. *J Am Podiat Med Assn*., 97(6): 447-456.
15. Masumoto, K., Takasugi, S-I., Hatter, N., Fujishima, K. and Iwamoto, Y. (2007). A comparison of muscle activity and heart rate response during backward and forward walking on an underwater treadmill. *Gait Posture*. 25: 222-228.
16. Milgrom, C., Finestone, A., Segev, S., Olin, T. A. and Ekenman, I. (2003). Are over ground or treadmill runners more likely to sustain tibial stress fracture. *Br J Sports Med*., 37: 160-163.
17. Murray, M. P., Spurr, G. B., Sepic, S. B., Gardner, G, M. and Mollinger, L. A. (1985). Treadmill vs floor walking: Kinematic, electromyogram, and heart rate. *J Appl Physiol*., 59(1): 87-91.
18. Schneider, C. and Capaday, C. (2003). Progressive adaptation of the soleus H-reflex with daily training at walking backward. *J Neurophysiol*. 89: 648-656.
19. Spendiff, O., Longford, N. T. and Winter, E. M. (2002). Effects of fatigue on the torque-velocity relation in muscle. *Br J Sports Med*., 3(6): 431-435.
20. Thorstensson, A. (1986). How is normal locomotor programme modified to produce backward walking? *Exp Brain Res*., 61: 664-668.
21. Chen, L-Y., Su, F-C. and Chliang, P-Y. (2000). Kinematic and EMG Analysis of Backward Walking on Treadmill. Proceedings of the 22nd Annual EMBS International Conference (pp.22-28).
22. Van Ingen Schenau, G. J. (1980). Some fundamental aspects of the biomechanics of over ground versus treadmill locomotion. *Med Sci Sports Exerc.*, 12(4): 257-261.

23. Wall, J. C. and Charteris, J. (1980). The process of habituation to treadmill walking at different velocities. *Ergonomics*, 23(5): 425-435.
24. Wall, J. C. and Charteris, J. (1981). A kinematic study of long-term habituation to treadmill walking. *Ergonomics,* 24(7): 531-542.
25. Wass, E., Taylor, N. F. and Matsas, A. (2005). Familiarization to treadmill walking in unimpaired older people. *Gait Posture*. 21: 72-79.
26. Wall, J. C. and Charteris, J. (1980). The process of habituation to treadmill walking at different velocities. *Ergonomics*, 23(5): 425-435.
27. Wall, J. C. and Charteris, J. (1981). A kinematic study of long-term habituation to treadmill walking. *Ergonomics,* 24(7): 531-542.

Corresponding Author
Baljinder Singh Bal, Ph.D.
Guru Nanak Dev University, Amritsar-143002 (Punjab), INDIA
Tel. No.: +91-9876134130
E-mail: *bal_baljindersingh@yahoo.co.in*

Received: December 2011
Accepted: February 2012