Pilot evaluation of a wheelchair accessible treadmill

A.T. CRAMER[a,b]; A.P. KARPINSKI, ME[a]; R. RODRIGUEZ, ME[a]; L. GUO, ME[a,b]; N. WESTING[b]; W.M. RICHTER, Ph.D.[a,1]
[a] *MAX mobility LLC*
[b] *Vanderbilt University*

Abstract. This pilot study tested the hypothesis that exercising on a wheelchair accessible treadmill improves cardiovascular fitness for manual wheelchair users without adverse effects on propulsion biomechanics or shoulder pain. Three manual wheelchair users participated in 30 minute exercise sessions three times per week for six-weeks using self-selected programs on a wheelchair accessible treadmill. Exercise capacity and propulsion biomechanics were assessed before and after the six week program. On average, subjects displayed increases in maximum VO_2 (22.9%) and maximum heart rate (9.6%), while resting heart rate decreased (14.7%). Propulsion biomechanics and shoulder pain did not change. There were no adverse effects associated with extended use of the treadmill. The results suggest that persons with paraplegia can improve cardiovascular fitness through the regular aerobic exercise with a wheelchair accessible treadmill.

Keywords: Biomechanics, Cardiovascular Fitness, Exercise, Paraplegia, Propulsion, Treadmill, Wheelchair

Introduction

The prevalence of obesity in manual wheelchair users (MWUs) exceeds that of the general population by more than 200% [1]. Obesity leads to secondary conditions such as cardiovascular disease, the leading cause of death for individuals with spinal cord injury[2,3].

Adapted treadmills have been shown to provide an effective means of improving the health of MWUs within the research environment[4]. A proof-of-concept wheelchair accessible treadmill prototype was developed by the investigators. This pilot study examines the effectiveness of the treadmill prototype in improving the health of three paraplegics.

Methods

Subjects signed and IRB-approved consent form prior to participation. Three subjects participated in the pilot and they were 33.7 ± 8.9 years old, 16.7 ± 9.7 years post injury, and ranged in neurologic level from T3 to T10.

[1] Corresponding Author.

During the initial and final visits, the subject's resting heart rate and blood pressure were taken. Propulsion biomechanics were recorded while the subject propelled continuously on multiple grades for a period of 90 seconds. Maximal VO_2 and maximal heart rate were determined through a protocol of steadily increasing speed and grade, until maximum endurance, the point at which the subjects could not keep up with the treadmill. The maximum VO_2 and peak heart rate were determined as the maximum values during this protocol. The difference between peak heart rate and heart rate recorded 2 minutes after propulsion ceased was recorded as Heart Rate Recovery. Finally, subjects completed the Wheelchair Users Shoulder Pain Index (WUSPI) [5].

Subjects exercised three times per week for 30 minutes. They were free to choose their own exercise program(s) during the session, which included sprints, hills, random, fat burn, manual, and custom programs. The subjects were able to adjust the intensity level of the exercise programs to correspond to their own abilities.

Figure 1: The treadmill has a large propulsion deck, a ramp for boarding, and a dynamic safety system.

Results

All subjects were able to independently board and operate the treadmill safely without encountering any adverse events. Metabolic and biomechanic measures were compared from the pre- and post-exercise assessment using a two-way ANOVA. With the small sample size, differences were determined to be significantly significant for P values less than 0.10.

Table 1: Metabolic Measures

	*Maximum VO_2 (L/min)		*Maximum HR (bpm)		HR Recovery (bpm)		*Resting HR (bpm)	
Subject	Pre	Post	Pre	Post	Pre	Post	Pre	Post
A	1.22	1.42	177	187	60	61	75	59
B	0.77	1.21	168	193	72	78	83	71
C	1.57	1.73	154	167	47	63	68	63
Mean	1.18	1.45	166	182	60	67	75	64
SD	0.40	0.26	12	14	13	9	8	6

** indicates statistical significance at P < 0.1*

Metabolic measures for the subjects are presented in Table 1. Maximum VO_2 increased following the 6 week exercise program. The VO_2 increase averaged 22.9%

and was statistically significant (P=0.093). Maximum heart rate for each subject also increased by 9.6%, (P=0.073). In addition, resting heart rate of each subject decreased from pre- to post training an average of 14.7% (P=0.076). The resulting handrim propulsion biomechanics, shown in Table 2, showed no differences from the pre- to post testing. The pretest WUSPI evaluations presented an average score of 10.7 ± 17.6, ranging from 0 - 31. None of the subjects indicated that exercise on the treadmill induced, prolonged, or aggravated any form of shoulder pain that they possessed prior to participation.

Table 2: Propulsion Biomechanics

	Peak Force (N)		Push Angle (Deg)		Cadence (Push/min)	
Subject	Pre	Post	Pre	Post	Pre	Post
A	96	89	69	88	53	37
B	79	93	98	96	64	65
C	128	130	89	87	62	65
Mean	101	104	85	90	60	56
SD	25	23	15	5	6	16

Conclusion

MWUs face a higher risk for the developing cardiovascular disease as well as UE pain and injury. The results of this pilot study suggest that MWUs can improve cardiovascular fitness through regular aerobic exercise on a wheelchair accessible treadmill with no adverse side effects.

Acknowledgements

This study was funded by the National Institutes of Health grant #1R43 HD052311-01

References

[1] Weil E, Wachterman M, McCarthy EP, Davis RB, O'Day B, Iezzoni LI, Wee CC. Obesity Among Adults With Disabling Conditions. JAMA 2002; 288: 1265-1268.

[2] Myers J, Lee M, Kiratli J. Cardiovascular disease in spinal cord injury: an overview of prevalence, risk, evaluation, and management. Am J Phys Med Rehabil. 2007; 86: 142-153.

[3] Gass GC, Camp EM, Davis HA, Eager DD, Grout L. The effects of prolonged exercise on spinally injured subjects. Medicine and Science in Sports and Exercise. 1981;13(5):277-283.

[4] Whipp BJ, Wasserman K. Oxygen uptake kinetics for various intensities of constant-load work. Journal of Applied Physiology 1972; 33(3):351-356.

[5] Curtis KA, Roach KE, Applegate EB, Amar T, Benbow CS, Genecco TD, Gualano J. Development of the Wheelchair User's Shoulder Pain Index (WUSPI). Paraplegia. 1995;33(5):290-3.