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The Effect of Therapeutic Exercise on Cardiac Stress in Patients With Stroke

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국문요약

치료적 운동이 뇌졸중 환자의 심혈관 부담에 미치는 영향

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본 연구는 급성기가 지난 뇌졸중 환자를 위한 치료적 운동 프로그램이 심박동수에 미치는 영향과 부가적으로 뇌졸중 환자의 기능적 상태에 따라 치료적 운동 형태를 알아보기 위해서 시행되었다. 대상자는 뇌졸중이 발생한지 3개월이 지난 23명의 환자이었다. 심박동수의 변화는 대상자가 각자의 치료적 운동을 수행하는 동안 Polar Vantage XL Heart Rate Monitor를 사용하여 측정하였다. 그 결과, 치료적 운동 동안 환자의 기능 수준 및 발병 기간에 따른 심박동수와 치료 형태의 차이는 없었다. 또한 전체 치료 시간 중 목표심박동수에 도달하는 시간은 2.47%에 불과하였다. 이는 치료적 운동이 뇌졸중 환자에게 과도한 심혈관 부담을 주지 않을 뿐만 아니라 유산소 훈련의 효과는 거의 존재하지 않음을 의미한다. 따라서 환자의 상태에 적절하고 유산소 훈련 효과를 고려한 치료적 운동 프로그램의 구성이 필요하다.

핵심단어: 뇌졸중; 심박동수; 치료적 운동.

Introduction

Stroke is the leading cause of major disability in older koreans (Sin, 2002). Because the effects of stroke are chronic, long-term management is necessary. Many studies have shown that function in stroke patients improves immediately after completion of a supervised therapy program, but long-term follow-up has been discouraging. Patients who have been monitored for 1 year after the completion of an inpatient rehabilitation program have shown declines in function (Davidoff et

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al, 1991; Kwakkel et al, 1997). Thus clinician must emphasize to both the patient and family that the exercise program should be continued even after discharge from the hospital (Shankar, 1999).

The overall aim of current stroke rehabilitation techniques is to recover neuromuscular function (Gresham et al, 1995). Thus many physical therapists have focused on movement re-education techniques such as neuromuscular development treatment and proprioceptive neuromuscular facilitation for rehabilitation of stroke patient. One aspect of therapy for poststroke patients that has received little attention is the extent of cardiovascular stress induced by physical rehabilitation. The aim of rehabilitation therapy after stroke is to maximize the patient's participation in society and his or her well-being while reducing stress on the family (Wade, 1999).

In cases of subacute and chronic stroke patients, aerobic capacity is important for the abilities to participate in society. But studies have shown that hemiparetic patients have low endurance to exercise, which may be due to reduced oxidative capacity of the paretic muscles, a decreased number of motor units available for recruitment, and overall reduced endurance (Potempa et al, 1996; Tangeman et al, 1990). The American College of Sports Medicine guidelines (1990) suggest that achieving an aerobic training effect requires exercise of large muscle groups at a frequency of 3 to 5 times a week, for a duration of 20 to 60 minutes, and at an intensity of 60% to 90% of the maximal heart rate (HR).

Awareness of the demands that various interventions place on the cardiovascular system is important, not only to ensure patient safety but also to inform activity prescription when aerobic training is a therapeutic goal (Marilyn et al, 2002). However, the information needed to ascertain the aerobic component of poststroke therapeutic sessions has not been documented.

The main purpose of this study was to investigate the effect of a routine physical therapy program on heart rate after stroke. The secondary purpose was to identify type of therapeutic activities and time spent in therapy.

Methods

Subjects

Twenty three stroke participants were recruited from the rehabilitation center of Bundang Jeasang hospital. Table 1 shows demographic and clinical characteristics of patients (8 infarction vs 15 hemorrhage; 11 outdoor walking vs 12 indoor walking). The mean age and body mass index were 50.3 years and 24.2 kg/m^2, respectively. The mean time since stroke onset and mean HR_{rest} were 11.7 months and 70.5 beat/min, respectively. Requirements for subjects used in this study were: (1) they must have the ability to participate and learn rehabilitation pro-

Table 1. Demographic and clinical characteristics of poststroke patients (N=23)

Characteristics	Mean±SD
Age (yr)	50.3±10.0
Body mass index (kg/m^2)	24.2±3.1
Duration of onset (mon)	11.7±9.8
Cause	
Infarct	15(65.2%)
Hemorrhage	8(34.8%)
Functional status	
Outdoor walking	11(47.8%)
Indoor walking	12(52.2%)
HR_{rest} (beat/min)	70.5±8.6

gram, (2) they must to be passed at least 3 months from the onset of stroke, (3) they must have the ability to walk independently. Patients with pacemaker, recent cardiac disease, or unstable medical problems were excluded.

Procedures

Heart rate and therapeutic activity type and time were monitored during individual physical therapy. Therapy times were 20~30 minutes. Participants wore a Polar Vantage XL Heart rate Monitor[1)] (Figure 1) 2 cm below the nipple to measure heart rate during PT. In cases of inadequate contact between the chest wall and the sensor, conductive gel was applied. Recording near strong electromagnetic sources was avoided because interference from sources can yield inaccurate hear rate data. Just before the therapy, baseline HR_{rest} was obtained during quiet lying at 15-second intervals for 1 minute.

In addition to heart rate, the observer recorded therapeutic activities in which the patient engaged in terns of duration, type. The type of activities were categorized as mat, standing, walking, or inactivities (Table 3). During therapy, variables associated with heart rate monitoring included mean heart rate (HR_{mean}), peak heart rate (HR_{peak}), age-predicted maximal heart rate ($HR_{max\text{-}pred}$) attained using the formula $HR_{max\text{-}pred}$ = 220-age. The HR_{target} zone was determined by using the most common clinical method - the Karvonen formula [HR_{target} zone = 40~85% ($HR_{max\text{-}pred}$ - HR_{rest}) +HR_{rest}] . Recorded heart rate data were averaged over 1-minute intervals.

Results

Table 2 shows duration and type of

1) Polar Electro Oy, FIN-90440, Finland

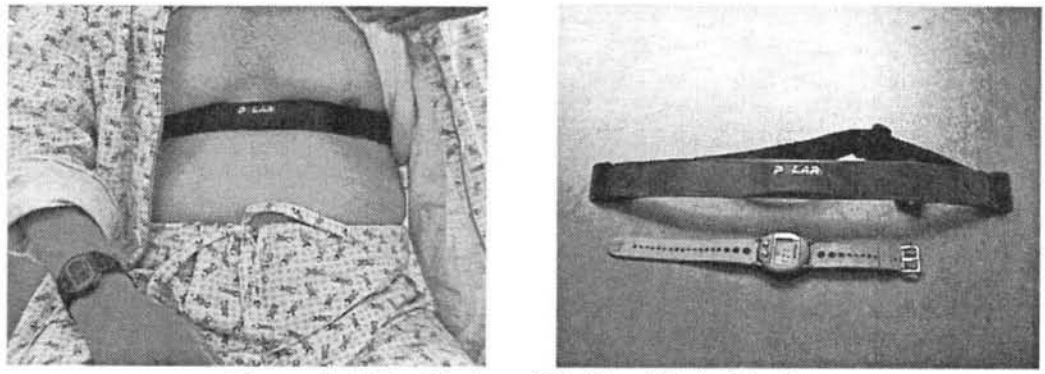

Figure 1. Polar Vantage XL Heart Rate Monitor

therapeutic activities at functional levels (outdoor and indoor walking). In the case indoor walking patients, the percentage of time spent on the mat, standing, walking, and inactivity of total therapy time was 44, 22, 5 and, 29, respectively. In the case outdoor walking patients, the percentage of therapy time was 41, 29, 5,

Table 2. Therapy times at functional levels (Unit: min)

	Outdoor walking group	Indoor walking group
Activity		
Mat activity		
U/E strengthening	2.8±2.2	2.6±2.4
L/E strengthening	4.5±1.5	4.7±1.7
Whole body activity*	2.0±1.9	1.8±2.9
Movement re-education	.0±.0	.4±.9
Standing activity		
Balance training	1.3±1.7	2.6±3.6
Weight shifting	1.9±2.0	1.2±1.1
Gait skill training	1.6±2.6	3.0±1.3
Walking		
Walking without resistance	.6±.9	.3±.7
Walking with resistance	.4±.8	.8±1.5
Inactivity**	6.2±2.9	5.6±1.9

*Whole body activity: activities such as bridge exercise

**Inactivity: education, passive stretching, passive range of motion exercise

and 25, respectively. There were no significant differences in time of activities between functional levels.

Table 3 shows HR responses during PT. T-test results indicated no significant differences in heart rate variables between time after stroke onset (Table 4) and functional levels (Table 5). On average, heart rate responses were below. The percentage of time in the HR_{target} zone of total time spent in PT was 2.5. At no time did the heart rate response of any patient surpass the upper limit of the HR_{target} zone.

Table 3. HR response during physical therapy

HR response	Mean±SD
HR_{mean} (beat/min)	87.0±11.6
HR_{peak} (beat/min)	99.4±16.0
HR_{mean} % $HR_{max\text{-}pred}$*	51.3±6.7
HR_{peak} % $HR_{max\text{-}pred}$**	58.6±9.1
Time in HR_{target} zone(%)	2.5±5.4

*HR_{mean} % $HR_{max\text{-}pred}$: ($HR_{mean/HRmax\text{-}pred}$) ×100

**HR_{peak} % $HR_{max\text{-}pred}$: ($HR_{peak}/HR_{max\text{-}pred}$) ×100

Table 4. HR response during therapy in time after stroke onset (Unit: beat/min)

	Before 6 months	After 6 months
Activity		
Mat activity		
U/E strengthening	79.0±10.5	79.7±7.2
L/E strengthening	90.0±20.2	85.4±8.5
Whole body activity*	85.0±6.3	82.8±11.9
Movement re-education	81.0±1.3	77.0±4.2
Standing activity		
Balance training	97.2±23.2	86.4±8.3
Weight shifting	90.5±16.3	80.3±4.6
Gait skill training	94.7±16.3	86.8±13.2
Walking		
Walking without resistance	90.5±27.6	76.0±6.8
Walking with resistance	94.0±15.4	109.0±7.1

*Whole body activity: activities such as bridge exercise

Discussion

Endurance after stroke is compromised to a level that limits basic daily functioning. Thus, both safety and aerobic training effect of therapeutic exercise are important to subacute and chronic stroke patients. The main purpose of this study was to investigate the effect of a routine physical therapy program on heart rate after stroke. The secondary purpose was to identify the type of therapeutic activities and time spent in therapy.

The main finding of this study was that the therapeutic exercise for stroke did not provide significant cardiovascular stress. By using a conservative calculation of threshold HRtarget levels, we observed the aerobic training time of exercises was negligible (2.47%)(Table 3). The mean heart rate and peak heart rate during therapy was 86.96 and 99.39, respectively. This meant that therapeutic exercise was safety but, did not reflect a metabolic stress sufficient to improve cardiovascular fitness.

This findings were inconsistent with those identified by Roth et al (1992). However, their investigation failed to calculate an HRtarget zone, just calculated change heart rate from HR_{rest} to HR_{peak}.

According to studies of Roth et al (1992) and Marlin et al (2002), the activities that elicited the greatest heart rate responses were mainly standing activities. Our findings were similar to their results.

Table 5. HR response during therapy at functional levels

	Outdoor walking	Indoor walking
Activity		
Mat activity		
U/E strengthening	77.6±8.2	81.3±8.1
L/E strengthening	83.6±10.2	90.1±15.7
Whole body activity*	84.3±12.1	83.1±7.3
Movement re-education		78.0±4.2
Standing activity		
Balance training	90.8±22.1	91.1±14.2
Weight shifting	81.3±5.0	85.1±13.5
Gait skill training	84.4±9.2	91.8±15.9
Walking		
Walking without resistance	76.67±8.1	85.00±21.7
Walking with resistance	92.00±21.2	105.33±8.1

*Whole body activity: activities such as bridge exercise

But, we documented that approximately one forth of PT treatment time was spent performing activities in standing. In contrast, Goldie et al (1996) reported that about half of treatment time was dedicated to participating activities in standing. In our study, many parts of PT treatment time was spent in mat activities (lying position) and inactivities.

Assertions have been made that physical therapists have a poor understanding of exercise physiology and prescription (Lamb and Frost, 1993; Paley, 1998). Because lack of motor and postural control is often the most obvious limiting factor in terms of functional recovery, emphasis on improving neuromuscular function is understandable.

In chronic stroke, However, exercise program to improve endurance or aerobic capacity is necessary. In addition to, therapists effort to reorganize the type of therapeutic exercise according to functional levels.

Conclusion

Therapeutic exercise for stroke did not appear to pose risks of excessive overload to cardiovascular system nor did they appear to elicit adequate cardiac stress to induce a training effect. Many parts of PT treatment time was spent in mat activities and inactivities. Because the majority of poststroke patients have limited exercise capacity, therapists may have respect to exercise programs for aerobic training.

References

American College of Sports Medicine. Position statement on the recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness in healthy adult. Med Sci Sports Exerc. 1990;22:265-274.

Davidoff GN, Keren O, Ring H, et al. Acute stroke patients: Long term effects of rehabilitation and maintain of gains. Arch Phys Med Rehabil. 1991;72:869-873.

Goldie PA, Matyas TA, Evans OM, Deficit and change in gait velocity during rehabilitation after stroke. Arch Phys Med Rehabil. 1996;77:1074-1082.

Kwakkel G, Wagenaar RC, Koelman TW, et al. Effects of intensity of rehabilitation after stroke. A research synthesis. Stroke. 1997;28:1550-1556.

Lamb S, Frost H. Exercise-the other root of our profession. Physiotherapy. 1993;79:772.

Paley CA, A way forward for determining optimal aerobic exercise intensity? Physiotherapy. 1998;84:620-624.

Potempa K, Lopez M, Braun LT, et al. Physiological outcome of aerobic exercise training in hemiparetic stroke patient. Stroke. 1995;26:101-105.

Roth EJ, Mueller K, Green D. Cardiovascular response to physical

therapy in stroke rehabilitation. NeuroRehabilitation. 1992;2:7-15.

Shankar K. Exercise Prescription. Philadelphia, Hanley & Belfus, 1999.

Sin JM. Complication in stroke. J Korean Acad Fam Med. 2002;23:1:13-22.

Wade D. Rehabilitation therapy after stroke. Lancet. 1999;354:177-178.