Abstract

The main aim with he present study was to evaluate treadmill training versus walking outdoor in order to improve quality aspects like step length, step width, cadence and quantitative aspects like endurance, walking speed and distance in walking. A secondary aim was to evaluate factors that might be influential in retrieving walking capacity.

The results indicate that treadmill walking achieved improved function in less time and regarding bilateral step length with higher degree of symmetrical use. The treadmill group gained increase in walking speed and distance, equally long and longer step length bilaterally in less time than the outdoor walking class supports the notion exercises on a treadmill walking is an effective and important tool in rehabilitation. The patients were well past the acute period of time after stroke, the fact that both treadmill and walking outdoors did improve in functional activities supports the importance of "booster doses" of rehabilitation in order to maintain physical function levels.

Improving gait after stroke – treadmill or walking; quantity or quality

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Introduction

Walking capacity is an important aspect of stroke rehabilitation both regarding endurance, functional activities like ADL and as a primary goal expressed by the patient (Globas, Macko & Luft, 2009). Different approaches are used in the rehabilitation of stroke patients in order to enhance and improve walking capacity, and there are different options available in view of which aspect of walking that is being considered (States, Pappas & Salem, 2009, Tang et al., 2009, Moseley, Stark, Cameron & Pollock, 2005). In order to enhance walking in the acute stage the therapist often focus on stability, balance and quality of movement whereas in the chronic stage functional aspects , endurance and quantity, how long how fast become more at focus (Peurala, Airaksinen, Jäkälä , Tarkka & Sivenius, 2007, van de Port, Kwakkel & Lindeman 2008).

There are very few studies on walking exercises outdoors compared to walking indoors despite the advantages this must have considering that most patients with stroke return home. One of the options for an independent living and domestic life is that you can walk indoors and outdoors. Task oriented training is recommended in the acute rehabilitation to gain skill for patients with stroke (Langhammer & Stanghelle 2000, Pollock, Bær, Pomeroy & Langhorne 2007). One would assume that walking outdoors is beneficial training if you want to improve this skill. Walking outdoors, on the other hand, is not a goal in itself and it is the goal of the activity that will be steering for what is the important aspect of the performance. If the goal is to walk to the grocers store 2 km down the road or to walk fast across a street there is probably a need for endurance, power and strength whereas reducing pain or to economize walking because of asymmetry need another approach. Walking parameters like bilateral stride length, step width and cadence are part of a qualitative aspect of gait where one would assume a symmetrical stride length, narrow step width and a reasonably low cadence would indicate a better performance. So, the question is quantity or quality, or perhaps both?

Treadmill walking has been shown to be a valuable therapeutic tool for improving walking patterns post stroke (Ada, Dean, Hall, Bampton & Crompton, 2003). It is also effective in enhancing endurance (Macko et al., 2005). Although treadmill training does not seem to enhance performance more than ordinary walking exercises in the acute stage for (Nilsson et al.,2001, Moseley, Stark, Cameron & Pollock, 2005, Dickstein, 2008), it might be beneficial in improving gait in the chronic stage but a question is, will exercise gain transfer to walking over ground?

The main aim with he present study was to evaluate treadmill training versus walking outdoor in order to improve quality aspects like step length, step width, cadence and quantitative aspects like endurance, walking speed and distance in walking. A secondary aim was to evaluate factors that might be influential in retrieving walking capacity.

Methods

A single- blind randomised controlled trial was set up. Patients were tested within the first day after arriving, and were randomised into two groups directly after the test, by a person not involved in the study: one group for treadmill exercises and the other for outdoor walking. Participants were informed about the study and participation was voluntary. The study was approved by the Regional Committee of Medical Research Ethics.

Inclusion criteria were neurological impairment and age above 50 years. Exclusion criteria were barriers to taking part in a physical rehabilitation programme, insufficient language, an unstable cardiac status, neurosurgery and a pre-morbid history of orthopedic problems or any problems that would prevent patients from walking.

Tests

The Motor Assessment Scale, item 3 was chosen to evaluate balance as the persons entered the programme. Item scores in the test range from 0 to 6, and the total scores range between 0 and 48 (Carr & Shepherd, 1985).

The 6-Minute Walk Test length and gait speed were recorded (Guyatt et al., 1985). The participants were asked to walk as fast as they could for 6 minutes. The 6-Minute Walk Test was also used to assess exercise tolerance (Larsen, Aarsland, Kristiansen, Haugland & Dickstein, 2001), thus measuring functional exercise capacity.

A 1o-metre walk test was performed by walking ten metres, with markers on the heels on both the affected and the intact foot, to measure quality of walking. The walk - way was 14 metres long, with 2 metres for warming up and 2 metres for slowing down, as also used in other studies (Ada, Dean, Hall, Bampton & Crompton, 2003). The participants were instructed to walk as fast and as safely as they could. Gait speed was measured with a stop-watch.

The patients were tested on arrival at the clinic (test 1) and at the end of the intervention period (test 2). The participants could use assistive devices and take a rest during the tests. An experienced investigator, well known with the tests, and blinded to group allocation, performed all tests in a separate section of the recreational centre.

Intervention

The group randomised to the treadmill exercises should do walking exercises five days a week during the period. The participants walked on the treadmill, and the exercises were carried out with the treadmill in a flat position and the participants could use support if needed. The working load was determined in co-operation with the participants to a level they felt comfortable with and they felt no insecurity in balance or discomfort otherwise.

The group randomised to outdoor walking also exercised 5 days a week at a comfortable speed and with the use of ordinary assistive devices when necessary. The walk was performed regardless of weather conditions, and the intention was a 30- minute continuous walk.

The other activities in the physiotherapy department were the same in the two groups.

Statistical analysis

Descriptive statistics are presented as mean and standard deviation (SD). An independent t-test was used to assess baseline differences. First, a multiple regression analysis was performed where 6 -MWT distance, 10m walking speed and step variables was entered as dependent variables separately and all other variables were entered as independent variables in order to find the significantly correlated variables. Final models were then analyzed with a the same dependent variables but now only with the significantly correlated variables time after stroke, time exercising, group assignment and gender independent variables (Tabachnick & Fidell, 2001). Preliminary graphical analysis determined that all applicable variables met the assumption of normality and that no significant outliers existed. Statistical significance was set at $p<0.05$.

Results

A total of 39 persons were initially included in the study with baseline tests. Five persons dropped out, three in the treadmill group and two in the walking outdoor group. Four participants, two in each group, were returned to the hospital because of acute symptoms, and one in the treadmill group, discontinued the stay for personal reasons. There were no baseline differences between the groups, and the length of stay was equal in the two groups (mean 2.5 weeks) (Table 1). Group activities and exercises were carried out five days a week, and during weekends only self - training was performed. The mean treadmill speed during exercise was 0.5 m/s, with a range of 0.4 to 1.1 m/s and a flat surface. The mean time per session for treadmill walking was 12 minutes, and the total exercising time was 107 minutes. The outdoor walks were carried out at a comfortable walking speed. The time spent exercising depended on the weather conditions, but was on average 29 minutes per session. The total mean time for outdoor walking was 316 minutes. Thus, significantly less time was spent on the treadmill than on walking exercise outdoors (p=0.02). The groups were supervised by physiotherapists and the participants were active, and compliance to their respective programme was 100%.

Table 1

A multiple regression analysis including all independent variables explained 57% of walked distance in 6-Minute Walk test (F = 4.5, p=0.002). A model 1 with the significantly correlated independent variables: group assignment, time exercising , gender and time after stroke, explained 51% of 6-Minute Walking Test (F=7.0, p=0.001) (Table 2), 43% of 10m walking speed (F=5.1, p=0.003)(Table 3), 39% of right stride length (F=4.3, p=0.008) (Table 4), 41% of left stride length (F=4.8, p=0.005) (Table 5), 15% of step width (F=1.2, p=0.33)(Table 6) and 29% of cadence (F=2.7, p=0.05) (Table 7). A final model 2 with independent variables group assignment and time exercising explained 28% of 6-Minute Walking Test (F=5.6, p=0.009), 28% of 10m walking speed (F=5.6, p=0.009), 21% of right stride length (F=3.9, p=0.03), 19 % of left stride length (F=3.4, p=0.04), 15% of step width (F=2.5, p=0.09) and 22% of cadence (F=4.2, p=0.03).

There were no differences in use of assistive aids between the groups on arrival to the clinic or at departure.

Tables 2-7

Discussion

The main results of this study indicate that exercise with treadmill walking improve walking speed, distance and stride length bilaterally in less time than outdoor walking. Treadmill walking has been reported by others to be an effective tool in the rehabilitation of stroke patients but the shorter duration of exercise in combination with both qualitative and quantitative improvements in walking patterns have not, to our knowledge , been shown before (Ada, Dean, Hall, Bampton & Crompton, 2003, Macko et al., 2005). One could expect that task oriented exercises like walking outdoors would improve walking capacity like increased distance / endurance and perhaps also increase in speed but there are no studies concerning stroke patients on this subject. Studies concerning outdoor walking are mainly focused at older persons and the results from these studies show that older persons going outdoors more often are less functionally impaired, score less for depression and are more socially active than their counterparts. Walking difficulty and fear of falls are, in those studies associated with going outdoors less (Rantakokko M et al., 2009).

Time after stroke is a variable that often have a negative influence on performance (Mayo et al., 1999). Despite that the patients were in the chronic phase of their stroke, the participants in both groups showed improvements in walking speed, distance and stride length (tables). The result indicates that intensive exercises are important in order to maintain walking capacities also in the chronic stages of stroke (Langhammer, Lindmark & Stanghelle, 2007). Exercise programmes for chronic stroke survivors are scarce and few studies are focused on improving and maintaining function past the acute three months of stroke (Langhammer, Lindmark & Stanghelle 2007, Askim, Mørkved &, Indredavvik 2006). Our study indicate that improving walking capacity by using a treadmill can transfer into increased endurance, walking capacity and better performance so that both quantity and quality is maintained.

The stay in a rehabilitation centre incorporated several activities, all very beneficial for improving physical function and supporting an empowering process. The results of this study must therefore be seen in the light of the participants´ total amount of activity, which was equal in the two groups. However, the difference in the exercise protocols was in the methods of walking exercise. We believe, therefore, that this difference must probably be the main explanatory factor for the improvement in the treadmill exercise group. The benefit of treadmill walking as an addition to rehabilitation programmes has also been shown in other studies (Ada, Dean, Hall, Bampton & Crompton, 2003, Kuys, Brauer, Ada & Russel, 2008, Chen, Patten, Kothari & Zajac, 2005).

The gender differences influenced performance so that women walked slightly slower, shorter distance and with shorter stride length and higher cadence. These differences have also been established among healthy elderly people (Morio et al., 1997, Langhammer & Lindmark 2007).

A weakness of this study is the relatively small groups and the limited period of follow-up. The results, therefore, must be interpreted with caution.

Conclusions

This study had as an aim to evaluate treadmill training versus walking outdoor regarding qualities in gait; bilateral step length, step width, cadence, walking speed and walking distance. Treadmill walking achieved improved function in less time and regarding bilateral step length with higher degree of symmetrical use. The treadmill group gained increase in walking speed and distance, equally long and longer step length bilaterally in less time than the outdoor walking class supports the notion exercises on a treadmill walking is an effective and important tool in rehabilitation. The patients were well past the acute period of time after stroke, the fact that both treadmill and walking outdoors did improve in functional activities supports the importance of “booster doses” of rehabilitation in order to maintain physical function levels**.**

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Table 1 Demographic data for patients included in the two different groups and significance levels at $p < 0.05$ for differences between the groups

Walking:	Treadmill n=21	Outdoor n=18	p-value
Men (n)	10	6	0.4
Women (n)	11	12	
Age (years,mean, SD)	74 (13.3)	75(10.4)	0.8
First time ever stroke (n)	17	16	0.5
Right / left hemisphere (n)	15 / 6	13 / 5	0.9
Time after stroke (days)	419 1034	349 820	0.8
Height (cm; mean,SD)	172(9.2)	167(11.6)	0.2
Weight (kg;mean,SD)	75(15.0)	67(17.3)	0.1
MAS 3 score	5.4	5.3	0.7
Assistive device arrival (n)	7	9	0.73
Assistive device departure (n)	5	6	0.53
Reduced sensation (n)	7	6	0.9
Length of stay (days;mean,SD)	15.9(5.3)	16.9(5.4)	0.6

Table 2 Regression analysis showing the association between 6-Minute Walk Test and independent variables group assignment, gender, and time exercising (model 1) and group assignment and time exercising (model 2).

variables	Beta	SE	p-values	R square
Model 1				
Group	-0.28	53.0	0.1	0.51
Gender	0.4	43.5	0.008	
Time exercising	0.5	0.13	0.006	
Time after stroke	-0.35	0.02	0.02	
Model 2				
group	-0.4	59.5	0.04	0.28
Time exercising	0.6	0.2	0.02	

Table 3 Regression analysis showing the association between 10m walking speed and independent variables group assignment, gender, and time exercising (model 1 and group assignment and time exercising (model 2).

variables	Beta	SE	p-values	R square
Model 1				
Group	-0.3	0.15	0.11	0.43
Gender	0.31	0.13	0.04	
Time exercising	0. 5	0.0	0.001	
Time after stroke	-0.33	0	0.04	
Model 2				
Group	-0.41	0.16	0.04	0.28
Time exercising	0.64	0	0.002	

Table 4 Regression analysis showing the association between dependent variable stride length right and independent variables group assignment, gender, and time exercising (model 1) and group assignment and time exercising (model 2).

variables	Beta	SE	p-values	R square
Model 1				
Group	-0.38	0.13	0.04	0.39
Gender	0.26	0.11	0.11	
Time exercising	0.39	0.0	0.04	
Time after stroke	-0.38	0	0.02	
Model 2				
Group	-0.48	0.14	0.02	0.21
Time exercising	0.51	0	0.02	

Table 5 Regression analysis showing the association between stride length left leg and independent variables group assignment, gender, and time exercising (model 1) and group and time exercising (model 2).

variables	Beta	SE	p-values	R square
Model 1				
Group	-0.41	0.12	0.03	0.41
Gender	0.26	0.10	0.09	
Time exercising	0.26	0.0	0.17	
Time after stroke	-0.45	0	0.006	
Model 2				
Group	-0.51	0.14	0.02	0.19
Time exercising	0.39	0	0.06	

Table 6 Regression analysis showing the association between step width and independent variables group assignment, gender, and time exercising (model 1) and group and time exercising (model 2).

variables	Beta	SE	p-values	R square
Model 1				
Group	0.42	2.5	0.06	0.15
Gender	0.14	2.1	0.9	
Time exercising	-0.07	0.006	0.8	
Time after stroke	-0.035	0.001	0.8	
Model 2				
Group	0.42	2.3	0.05	0.15
Time exercising	-0.06	0.006	0.8	

Table 7 Regression analysis showing the association between cadence and independent variables group assignment, gender, and time exercising (model 1) and group and time exercising (model 2).

variables	Beta	SE	p-values	R square
Model 1				
Group	-0.07	11.9	0.7	0.29
Gender	0.19	9.9	0.3	
time exercising	0.46	0.006	0.03	
Time after stroke	-0.19	0.005	0.3	
Model 2				
Group	-0.12	11.6	0.5	0.22
Time exercising	0.53	0.03	0.01	