Masterthesis Fysiotherapiewetenschap

Exercise and depression after stroke

A systematic review

Shuttle Walk Test in patients who suffered a stroke

A feasibility study

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“ONDERGETEKENDE

Bevestigt hierbij dat de onderhavige verhandeling mag worden geraadpleegd en vrij mag worden gefotokopieerd. Bij het citeren moet steeds de titel en auteur van de verhandeling worden vermeld.”

Dankwoord

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Nederlandse samenvatting

De invloed van bewegen op depressie bij mensen met een CVA

Doel-Dit review heeft als doel om te onderzoeken wat de invloed van bewegen is op depressie bij mensen met een CVA.
Methode-Een systematische zoektocht is gedaan naar (gerandomiseerde), gecontroleerde studies waarin patiënten met een CVA geïncludeerd waren en depressie als uitkomstmaat gemeten werd. Nadat de methodologische kwaliteit werd bepaald met de PEDro-schaal, is een best evidence synthese opgesteld.
Resultaten-Twee van zeven studies lieten een significant, positief effect zien van bewegen op depressie bij mensen met een CVA. De best evidence synthese toonde onvoldoende bewijs voor positieve effecten van bewegen bij mensen met een CVA.
Conclusie-Uit dit review kan niet geconcludeerd worden dat bewegen een positief effect heeft op depressie bij mensen met een CVA.

Trefwoorden: CVA ❑ depressie ❑ bewegen ❑ systematisch review

Een shuttle wandeltest bij mensen met een CVA

Doel-In deze studie wordt de toepasbaarheid onderzocht van de Shuttle Wandel Test (SWT) en de Shuttle Run Test voor kinderen met een cerebrale parese met GMFCS-niveau II (SRT-II) bij mensen met een cerebrovasculair accident (CVA).
Methode-Vijftien patiënten met een CVA voerden de SWT en de SRT-II uit om het maximale inspanningsvermogen te meten.
Resultaten-Significante verschillen werden gevonden wat betreft maximale hartslag en testduur tussen beide testen ten gunste van SRT-II. Er werd geen significant verschil gevonden in ervaren vermoeidheid (Borg-schaal).
Conclusie-De SRT-II is beter toepasbaar om het maximale inspanningsvermogen te meten van mensen met een CVA dan de SWT.

Trefwoorden: CVA ❑ maximaal inspanningsvermogen ❑ haalbaarheidsstudie ❑ Shuttle Walk Test

Abstract

Exercise and depression after stroke

Purpose-Aim of this review is to summarize the evidence from (randomized) controlled trials regarding the effects of exercise on depression or depressive symptoms in patients who had suffered a stroke.

Methods-Studies that included patients who suffered a stroke and measured an outcome concerning depression were systematically reviewed. After determining the methodological quality by the Pedro-scale, a best evidence synthesis was applied.

Results-Two out of seven studies showed significant differences between both groups, in favor of the intervention group. Best evidence synthesis showed insufficient evidence for positive effects of exercise on depression in patients who suffered a stroke.

Conclusion-From the studies included in the present review it cannot be concluded that exercise interventions had a positive effect on depression in patients who suffered a stroke.

Key Words: stroke ❑ depression ❑ exercise ❑ systematic review

Shuttle Walk Test in patients who suffered a stroke

Objective-To evaluate the feasibility of the Shuttle Walk Test (SWT) and the Shuttle Run Test for children with cerebral palsy at GMFCS level II (SRT-II) in patients who suffered a stroke.

Methods-Fifteen patients who suffered a stroke completed both the SWT and SRT-II to evaluate aerobic capacity.

Results-Significant differences were found in maximum heart rate and test duration in favor of the SRT-II. No significant difference was found in perceived exertion.

Conclusion-The SRT-II is more feasible to assess aerobic capacity in patients who suffered a stroke compared to the SWT.

Key Words: stroke ❑ aerobic capacity ❑ feasibility study ❑ Shuttle Walk Test

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Exercise and depression after stroke

A systematic review

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Background and Purpose-The effect of physical exercise on depression or depressive symptoms in patients who survived a stroke is unknown. Some systematic reviews show positive effects of exercise for treating depression, though no patients who had a stroke were included in these studies. Aim of this review is to summarize the evidence from (randomized) controlled trials regarding the effects of exercise on depression or depressive symptoms in patients who had suffered a stroke.

Methods-Studies that included persons after stroke and measured an outcome concerning depression were systematically reviewed until the 24th of January 2009. The electronic databases CINAHL, the Cochrane Library, EMBASE, MEDLINE and PEDro have been searched. After determining the methodological quality by the Pedro-scale, a best evidence synthesis was applied.

Results-Seven studies, with a large variety in exercise training, were included in this review. The Pedro-score ranged from 6 to 8. Three measuring instruments (GDS, HADS and BDI) were indentified for scoring depressive symptoms. Five studies showed no significant differences between the intervention group and control group

in depression scores. Two studies showed significant differences between both groups, in favor of the intervention group. Best evidence synthesis showed insufficient evidence for positive effects of exercise on depression or depressive symptoms in patients who had had a stroke.

Conclusion-From the studies included in the present review it cannot be concluded that exercise interventions had a positive effect on depression in patients who suffered a stroke. However, main goal of the studies was investigating the effects of exercise on physical impairments, and not on depression. Therefore probably only a part of all included patients suffered from depression; the actual number of patients with diagnosed depression was, in most studies, not reported.

Key Words: stroke ❑ depression ❑ exercise ❑ systematic review

Introduction

In the Netherlands each year approximately 30.000 persons suffer a stroke. Currently about 230.000 patients are living with the consequences of stroke (1). Patients who had had a stroke often experience physical impairments and reduced mobility (2-4). In addition, patients can suffer depressive symptoms. Depression is a common symptom in patients who had a stroke, with a prevalence ranging from 23% to 45% (5). The incidence of depression in patients who had a stroke is approximately 33% (6). Depression is known to increase disability and affect rehabilitation outcomes (7). In addition, patients with depression or depressive symptoms after stroke have also poorer functional status and decreased quality of life after the event (8, 9). As a result of the physical and psychological impairments patients suffer the risk of entering a vicious circle, with negative effects on quality of life (QoL) (Figure 1) (10-15).

Treatment of physical impairments in patients who had a stroke occurs separately to that of depression. Exercise, such like physical therapy, is used to deal with the physical impairments, while antidepressant drugs, in combination with psychotherapy, are provided against post stroke depression (16-18).

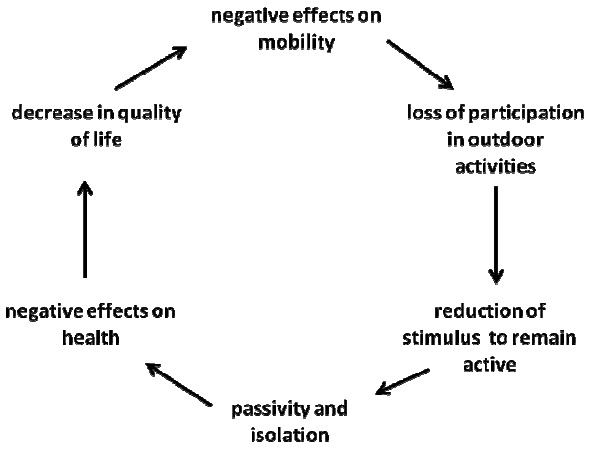

Figure 1. *Vicious circle of reduced mobility (15)*

However, the pharmacological treatment of depression after stroke often obtain limitations and negative side effects for the patient (19-23). Due to these impairments

researchers and physicians have been exploring new opportunities for treating depression.

Evidence for the positive effect of physical exercise on depression in healthy subjects and those who suffer from a chronic disease is increasing. At the same time it is suggested that participating in any form of exercise can prevent depression in healthy subjects and various patient populations (24-26). Although no patients who survived a stroke have been included in the above mentioned studies, physical exercise may be an alternative intervention for treating or preventing depression after stroke instead of pharmacological therapy and psychotherapy.

Aim of the present review is to summarize the evidence from (randomized) controlled trials regarding the effect of exercise on depression or depressive symptoms in patients who had had a stroke.

Methods

Criteria for selecting studies for this review

In this systematic review the following criteria were used for selecting the studies.

Inclusion criteria:

The selection procedure of the literature in this review consisted of two stages and was executed by two independent reviewers (MvhH and DB). First the studies were screened on title and abstract, where after the full text was screened. The following inclusion criteria were applied:

- Studies were randomized controlled trials (RCT) or controlled clinical trials (CCT)
- Studies were published in the Dutch, English or German language
- Reported intervention enclosed any type of physical exercise
- Studies included an outcome measure of depression
- Included participants suffered a stroke and were above 18 years

Exclusion criteria:

- Participants with cognitive impairments

Search strategy, data extraction and synthesis

Relevant studies were independently identified by two researchers (MvhH, DB) using the following electronic databases: CINAHL, the Cochrane Library, EMBASE, MEDLINE and the Physiotherapy Evidence Database (PEDro).

The search strategy used the following keywords: “stroke” (MeSH-heading) and “cerebrovascular accident”. For selecting the intervention: “exercise” (MeSH-heading), “exercise therapy” (MesH-heading), “training”, “physical education and training” (MeSH-heading), “physical exercise” and “physical training” were used. “Depression” (MeSH-heading), “Depressive disorder” (MeSH-heading) and “depressive symptoms” were used for selecting the outcome measures.

Next to these criteria the keywords: “clinical trial” (MeSH-heading), “randomized controlled trial” (MeSH-heading), “randomized clinical trial” and “controlled clinical trial” (MeSH-heading) were used to select the study design. Finally all keywords were combined for search strings in the different databases (Appendix 1).

The search strategy identified a set of potentially relevant references. Two researchers (MvhH and DB) screened the results for potentially eligible studies. When titles and abstracts suggested a study was potentially eligible for inclusion, a full paper copy of the report was obtained. Disagreements between the two researchers regarding a study’s eligibility were resolved by discussion until consensus was reached or, where necessary, a third independent researcher (MvO) acted as adjudicator.

Methodological quality of the studies eligible for inclusion was established using the “PEDro-scale” (Table 1). This instrument considers two aspects of trial quality, namely the internal validity and whether the study contains sufficient statistical information to make it interpretable (27, 28). A PEDro-score of ≥ 4 points classified the methodological quality as high (29). The author of this review (MvhH) and a second reviewer (DB) independently determined the PEDro-scores of each article. Cohen’s kappa (κ) was used to measure the level of agreement between both reviewers and classified according to Landis and Koch (30). Disagreements between the two researchers regarding a PEDro-score were resolved by discussion until consensus was reached.

***Table 1**: PEDro-scale (27, 28)*

Items		Score *No/Yes*
1.	Eligibility criteria were specified	0 / 1
2.	Subjects were randomly allocated to groups	0 / 1
3.	Allocation was concealed	0 / 1
4.	The groups were similar at baseline regarding the most important prognostic indicators	0 / 1
5.	There was blinding of all subjects	0 / 1
6.	There was blinding of all therapists who administered the therapy	0 / 1
7.	There was blinding of all assessors who measured at least one key outcome	0 / 1
8.	Measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups	0 / 1
9.	All subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analyzed by "intention to treat"	0 / 1
10.	The results of between-group statistical comparisons are reported for at least one key outcome	0 / 1
11.	The study provides both point measures and measures of variability for at least one key outcome	0 / 1

Best evidence synthesis

After scoring the methodological quality of the individual studies a best evidence synthesis was applied. For this synthesis the criteria set by Van Peppen et al. based on the methodological quality score of the PEDro scale was used (29). Studies were categorized into five levels of evidence: (1) strong evidence, (2) moderate evidence, (3) limited evidence, (4) indicative findings, (5) no or insufficient evidence (Table 2). Best evidence synthesis was executed independently by two reviewers (MvhH and DB). Disagreements between the two researchers regarding the levels were resolved by discussion until consensus was reached.

Table 2: *Best evidence synthesis by Van Peppen et al. (29)*

Strong evidence	Provided by statistically significant findings in outcome measures in -at least two high-quality RCTs, with PEDro scores of at least 4 points*
Moderate evidence	Provided by statistically significant findings in outcome measures in - at least one high-quality RCT and - at least one low-quality RCT (≤ 3 points on PEDro) or one high-quality CCT*
Limited evidence	Provided by statistically significant findings in outcome measures in - at least one high-quality RCT or - at least two high-quality CCTs* (in the absence of high-quality RCTs)
Indicative findings	Provided by statistically significant findings in outcome measures in at least - one high-quality CCT or low-quality RCTs* (in the absence of high-quality RCTs), or - two studies of a non-experimental nature with sufficient quality (in absence of RCTs and CCTs)*
No or insufficient evidence	- In the case that results of eligible studies do not meet the criteria for one of the above stated levels of evidence, or - in the case of conflicting (statistically significant positive and statistically significant negative) results among RCTs and CCTs, or - in the case of no eligible studies

* If the number of studies that show evidence is < 50% of the total number of studies found within the same category of methodological quality and study design (RCT, CCT or non-experimental studies), no
evidence will be classified.

Results:

After 31 studies were selected for inclusion, duplicates were removed and 19 studies were excluded (31-49) after screening the full text article. Seven studies, involving a total of 334 participants (range 20 to 106), met the inclusion criteria (Figure 2) (50-56). Time elapsed since stroke ranged from two days to six years post stroke. Six studies are randomized controlled trials (50-54, 56) and there is one modified random assignment, matched-pair control group design with repeated measures (55) included in this review. Main measuring instruments were the Beck Depression Inventory (BDI), the Geriatric Depression Scale (GDS) and the subscale depression of the Hospital Anxiety and Depression Scale (HADS).

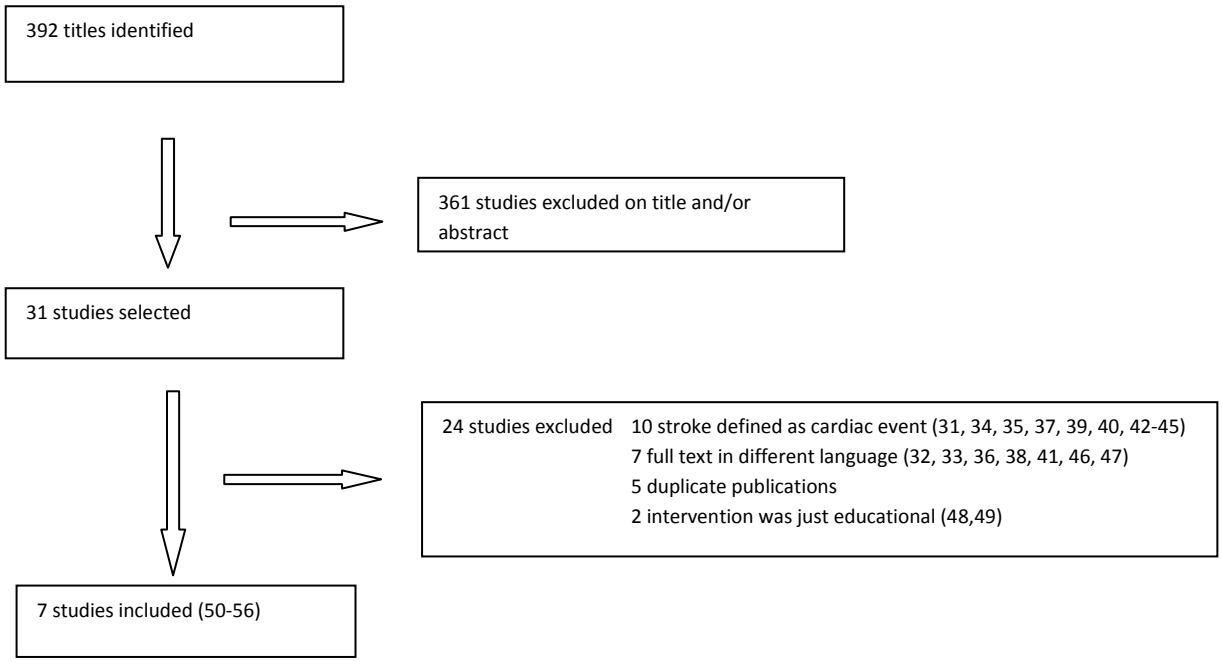

Figure 2: *Process of inclusion of studies for review*

The quality score of the studies ranged from 6 to 8 on the Pedro-scale (Table 3) (27, 28). According to the best evidence synthesis by Van Peppen et al. methodological quality of all these studies can be classified as high (29). The level of agreement between both reviewers, based on the overall PEDro-score, measured with Cohen's kappa (κ), was 0.77. According to Landis and Koch the level of agreement is substantial (30).

Table 3*: Methodological quality of included studies*

Studies	Items											
	1	2	3	4	5	6	7	8	9	10	11	Score
Morris, 2008 [53]	Y	1	1	1	0	0	1	1	1	1	1	8
Smith, 2008 [55]	Y	1	0	1	0	0	0	1	1	1	1	6
Lennon, 2008 [51]	Y	1	1	1	0	0	0	1	1	1	1	7
Mead, 2007 [52]	Y	1	1	1	0	0	0	1	1	1	1	7
Tseng, 2007 [56]	Y	1	0	1	0	0	1	1	0	1	1	6
Lai, 2006 [50]	Y	1	0	1	0	0	0	1	1	1	1	6
Ouelette,2004 [54]	Y	1	0	1	0	0	1	1	1	1	1	7

Exercise and depression

The characteristics of the included study are shown in Appendix 2.

Morris et al. (53) conducted a single-blinded randomized controlled trial to compare the effects of bilateral task training with unilateral task training on upper limb outcomes in early post stroke rehabilitation. Secondary outcome measure was the subscale depression of the HADS. The number of patients with depressive symptoms in this trial was not reported. No significant differences in HADS scores were found between the intervention and control group. Small (non-significant) improvements in HADS scores were found within both groups.

Smith and Thompson (55) applied a modified random assignment, matched-pair control group design with repeated measures. Purpose of their study was to explore the secondary benefits of treadmill training for patients in the chronic stage of recovery from stroke. Measuring instrument was the BDI. The actual number of patients with depressive symptoms was not reported. No significant differences in BDI scores were found between intervention and control group. However, a significant improvement in BDI scores was found within the intervention group.

Lennon et al. (51) conducted a single-blinded randomized controlled trial to evaluate risk factor reduction for cardiovascular events and health related quality of life following a 10-week cardiac rehabilitation program in patients who had a non-acute ischemic stroke. Measuring instrument was the subscale depression of the HADS. The number of patients with depressive symptoms in this trial was not reported. No significant differences in HADS scores were found between the intervention and control group. However, a significant improvement in HADS scores was found within the intervention group.

Mead et al. (52) performed an exploratory randomized controlled trial to determine the feasibility and effect of exercise training after stroke. Measuring instrument was the subscale depression of the HADS. The number of patients with depressive symptoms was not reported. No significant differences in HADS depression scores were found between the intervention and control group.

Tseng et al. (56) conducted a randomized controlled trial to evaluate the effects of a range-of-motion exercise program aimed at improving joint flexibility, activity function, perception of pain and depressive symptoms in a sample of bedridden patients who suffered a stroke. Measuring instrument was the GDS. The actual number of patients with depressive symptoms in this trial was not reported. Significant differences in

GDS scores were found between the intervention groups and control group, in favor of the intervention groups. No significant difference in GDS scores was found between both intervention groups.

Lai et al. (50) conducted a randomized controlled trial to evaluate the effects of exercise on depressive symptoms. Measuring instrument was the GDS. Within this trial, 22 patients with depressive symptoms at baseline were included. Significant differences in GDS scores were found between the intervention group and control group immediately post intervention. No significant differences in GDS scores were found six months post intervention between both groups. GDS-scores improved significantly within the intervention group compared to the control group.

Ouellette et al. (54) conducted a randomized controlled trial to evaluate the effects of supervised high-intensity progressive resistance training (PRT) on lower extremity strength, function and disability in older patients who had had a stroke. Secondary outcome measure was the GDS. The number of patients with depressive symptoms was not reported. No significant differences in GDS scores between the intervention and control group were found, though there were significant improvements in GDS scores within both groups.

Best evidence synthesis

Seven high-quality studies were included in this review. Five studies showed no significant differences between the intervention group and control group in depression scores (51-55).

Two studies showed significant differences between both groups, in favor of the intervention group (50, 56). Therefore best evidence synthesis by Van Peppen et al. (29) showed insufficient evidence for positive effects of exercise in treatment of depression or depressive symptoms in patients who suffered a stroke.

Clustering of outcome data was not executed, due to the diversity of measuring instruments and interventions within the individual studies.

Discussion

Aim of this review was to summarize the effects of exercise on depression or depressive symptoms in patients who had suffered a stroke. There is a good reason to expect exercise to affect depressive symptoms. It can be hypothesized that exercise could directly improve physical function and reduce disability, and disability affects mood. Thus, exercise might directly improve mood and reduce depressive symptoms via improved physical function (24). Exercise can also affect psychological function, including self-efficacy, coping and socialization. When self-efficacy is increased, quality of life is also likely to improve, especially when rehabilitation goals are achieved (9, 57).

To our knowledge this is the first review that focuses on the effects of exercise on depression in patients who had had a stroke. Although in most of the included studies in this review significant improvements were found within the intervention groups, no significant differences in depression scores were found between the intervention and control groups. The best evidence synthesis showed insufficient evidence for the effects of exercise on depression or depressive symptoms in patients who had had a stroke. These results do not support previous studies concerning the effects of exercise on depression scores in other patient groups, in which positive significant differences were found (58-61).

There are some considerations to be made interpreting the results of this review.

The number of patients suffering from a depression or depressive symptoms in most of the included studies was not reported. According to the review of Barker-Collo (5) approximately 23% to 45% of the participants of the included studies suffered from depression or depressive symptoms. Thus, the majority of the participants in the included studies of this review would not have suffered from depression or depressive symptoms at all. It is not likely to expect an improvement in depressive symptoms from the majority of the participants who had no depressive symptoms at baseline. However, the patients who did not suffer from depression or depressive symptoms heavily influenced mean depression scores. This might explain that no significant differences in depression scores were found after exercise intervention in five included studies (51-55). The study of Tseng et al. showed significant differences between the intervention group and control group, in favor of the intervention group,

though the actual number of patients with depressive symptoms was not reported (56). Only Lai et al. reported the exact number of patients who had depressive symptoms after stroke and showed significant differences between the intervention group and control group, in favor of the intervention group (50). Unfortunately, in this review no studies were found that included only patients who suffered a stroke with diagnosed depression. This is in contrast with studies that examined the effects of exercise on depression or depressive symptoms in other patient groups, in which patients with diagnosed depression were included only (58-61).

The author attempted to avoid bias in the review process by ensuring that all relevant studies through comprehensive, systematic searching of the literature were identified. However only studies in the English, Dutch and German language were included. Seven abstracts of selected studies (32, 33, 36, 38, 41, 46, 47) indicated useful information for this review, however because of another language, used in the full-text article, this information was not included in this review.

Participants in this review showed various types of lesion, severity of motor deficits and depressive symptoms and were included during different stages in stroke rehabilitation. Comparing the results of the studies involved was difficult, due to the heterogeneity within the sample. Meanwhile the difference in characteristics of participants is a common sight in stroke rehabilitation.

In addition, in this review any type of exercise is compared with no exercise or usual care as control group. A large variety exists in types of exercise programs in the included studies. In one study (56), involving older bedridden patients who suffered a stroke, intervention consisted of a range-of-motion program, while a progressive exercise program targeting strength, balance, endurance and upper extremity function for three times a week was set as intervention in another study (50). As mentioned earlier the number of studies that could be included was small. Therefore it was not possible for the author of this review to focus on one specific exercise intervention.

Depression and depressive symptoms can be measured, using several instruments. In this review three instruments were presented (BDI, GDS and HADS). Results of the studies involved should be interpreted with care, due to the different features of the measuring instruments. For example the BDI is used to measure the severity of depression. Its long form is composed of 21 questions, each designed to assess a specific symptom common among patients with depression (62). The BDI probably

provides an adequate measure of depression in a majority of patients who suffered a stroke, though it is not yet fully evaluated in this context (13). The GDS is a 30-item self-report assessment designed especially to identify depression in the elderly, but has also been validated for evaluating depression in patients who suffered a stroke (63). This measuring instrument can also contribute to diagnosing a depression (64). The HADS is a self screening questionnaire for depression and anxiety and has been validated for use in patients who suffered a stroke (65). It contains 14 questions, seven for anxiety and seven for depression. It can be used to detect depression and measure the severity of depression (66). To conduct a review focusing on one instrument however was not feasible due to the heterogeneity of the measuring instruments and lack of studies concerning exercise and depression.

Future research should examine optimal dose and exercise characteristics and their effects on patients who had a stroke, suffering from depressive symptoms, in different stages of recovery using sensitive measures of depression. In the case of a trial with a large population it might be possible to conduct sub-analysis concerning the effects of exercise on depression in patients who suffered a stroke.

Conclusions

From the studies included in the present review it cannot be concluded that exercise interventions had a positive effect on depression in patients who suffered a stroke. Health professionals should be careful to generalize the results of this review, due to the study limitations.

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Appendix 1

Search strategy

		PEDro	CINAHL	EMBASE en MEDLINE	Cochrane Library
#1	stroke[MeSH]		25649	31979	21586
#2	cerebrovascular accident[MeSH]		424	17114	510
#3	#1 OR #2		25787	46583	21777
#4	exercise[MeSH]		49521	38092	30085
#5	exercise therapy[MeSH]		361	504	3602
#6	training		52913	64201	22210
#7	physical education and training [MeSH]		929	1598	1134
#8	physical exercise		830	38092	895
#9	physical training		381	15076	662
#10	#3 AND (#4 OR #5 OR #6 OR #7 OR #8 OR #9)		4297	1189	1720
#11	Depression[MeSH]		36996	74212	2338
#12	Depressive disorder[MeSH]		984	74212	6388
#13	Depressive symptoms		3512	7466	1995
#14	#10 AND (#11 OR #12 OR #13)	5*	8293	89	141
#15	#14 and RCT filter		319	5	63**

* The PEDro database has been searched using the following keywords: stroke and exercise and depression.

** The number of “Clinical Trials” . No RCT filter could be used within this database.

Appendix 2

Characteristics of included studies

Study	Design	Participants	Intervention	Outcomes	Results	PEDro-score
Morris et al. 2008	RCT	Patients who had a stroke in the acute phase of recovery (N=106) Intervention n=56 Control n=50	1. Bilateral training with each arm simultaneously for 20 minutes a session, five weekdays a week over six weeks in addition to usual therapy (intervention group) 2.Unilateral training with the paretic upper limb for 20 minutes a session, five weekdays a week over six weeks in addition to usual therapy (control group)	HADS: subscale depression (HADS depression) Scored at baseline, six weeks and 18 weeks	No significant differences on HADS depression were found between both groups. (P=0.42) (non-significant) Improvements on HADS depression were found within the intervention and control group	8
Smith and Thompson, 2008	Modified random assignment, matched-pair control group design with repeated measures	Patients who had a stroke (N=20) Participants matched by side of hemiparesis and motor impairment Intervention n =10 Control n=10	1. 12 sessions of treadmill training over four weeks . 20 minute sessions under supervision. Weekly phone calls about the quality of the participants week and encouragement to record any life events (intervention group) 2.Weekly phone calls about the quality of the participants week and encouragement to record any life events (control group)	BDI Scored at baseline, after four weeks and after six weeks	No significant differences in BDI scores between intervention and control group were found. (P> 0.05) Significant improvement in BDI scores within the intervention group (P<0.001)*	6
Lennon et al. 2008	RCT	Patients who had a stroke (N=48) Intervention n=24 Control n=24	1.Usual care and a 10-week cycle ergometry program for twice a week, 30 minutes for each session, using either the upper or lower limbs (intervention group) 2.Usual care	HADS: subscale depression (HADS depression) Scored at week 1 and week 10	No significant differences in HADS scores between the intervention and control group Significant improvement in HADS scores within the intervention group (P=0.001)*	7
Mead et al. 2007	RCT	Patients who had a stroke, who were able to walk independently (N=66) Intervention n=32	1.Exercise training for 12 weeks (including progressive endurance and resistance training)(intervention group) 2.Relaxation therapy for 12 weeks (control	HADS: subscale depression (HADS depression)	No significant differences in HADS depression scores were found between the intervention and control group (P=0.49)	7

		Control n=34	group)	Scored at baseline, three months and seven months		
Tseng et al. 2007	RCT	Bed-ridden patients who had a stroke in residential care (N=59) Intervention 1 n= 21 Intervention2 n=21 Control n=17	1.Range of motion (ROM) protocol, self-assessment. Full ROM movements in six joints (shoulder, elbow, wrist, hip, knee and ankle), five times per joint, twice per day, six days per week for four weeks. Each session lasting 10-20 minutes. (intervention group 1) 2.ROM protocol (see intervention group 1). Physical help from a nurse in achieving maximum ROM. (intervention group 2) 3.Usual care (control group)	GDS, Chinese version (GDS-15) Scored at baseline and four weeks	Significant difference in GDS scores between intervention group 1 and control group (P=0.000)* Significant difference in GDS scores between intervention group 2 and control group (P=0.000)* No significant difference of GDS scores between intervention group 1 and intervention group 2	6
Lai et al. 2006	RCT	Patients who had a stroke who had completed acute rehabilitation (N=93) Intervention n=44# Control n=49##	1.Progressive exercise program targeting strength, balance, endurance and upper extremity function Three times a week for 36 sessions (intervention group) 2.Usual care (control group)	GDS Scored at three months (immediately post intervention) and nine months (six months post intervention)	Significant difference in GDS scores immediately post intervention between intervention group and control group (P<0.03)* No significant differences six months post intervention (P=0.07)	6
Ouellette et al. 2004	RCT	Patients who had a stroke, six months to six years following stroke (N=42) Intervention n=21 Control n=21	1.Progressive resistance training, three times a week for twelve weeks (intervention group) 2.Bilateral range of motion exercises for three times per week (control group)	GDS Scored at baseline and 12 weeks	No significant differences in GDS scores between the intervention and control group Significant improvements in GDS scores within the intervention (P<0.02)* and control group (P<0.01)*	7

RCT: randomised controlled trial
HADS: Hospital Anxiety and Depression Scale
BDI: Beck Depression Inventory
GDS: Geriatric Depression Scale
*= significant difference (P< 0.05)
#= 6 patients suffered from depressive symptoms
##= 16 patients suffered from depressive symptoms

Shuttle Walk Test in patients who suffered a stroke

A feasibility study

July 2009

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Shuttle Walk Test in patients who suffered a stroke

A feasibility study

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Abstract

Objective-To evaluate the feasibility of two protocols of the Shuttle Walk Test (SWT) in patients who suffered a stroke. Used protocols were the SWT and the Shuttle Run Test for children with cerebral palsy at GMFCS level II (SRT-II).

Design-A cross-sectional design was used to study the feasibility of the SWT and the SRT-II to assess aerobic capacity in patients who suffered a stroke.

Participants-Fifteen patients who suffered a stroke (eight men, seven women, mean age 70 ± 6.1 years) completed both the SWT and SRT-II. Patients had mild gait deficits and were able to walk independently.

Measures and Procedure-The SWT and SRT-II were conducted with at least three hours in between. Main outcome measures (means) were calculated for maximum heart rate, perceived exertion (Borg-scale) and test duration. Dependent t-tests were used to determine significant differences between the outcomes.

Results-Significant differences were found in maximum heart rate and test duration in favor of the SRT-II. No significant difference was found in perceived exertion.

Conclusion-The SRT-II is more feasible to assess aerobic capacity in patients who suffered a stroke compared to the SWT.

Key Words: stroke ❑ aerobic capacity ❑ feasibility study ❑ Shuttle Walk Test

Introduction

In the Netherlands stroke is a major cause of chronic disability, with increasing incidence particularly in elderly people. In addition, the stroke mortality rate is declining, which translates into a larger number of patients who survive a stroke (1). Many patients who suffered a stroke, continue to live with physical impairments, reduced mobility and muscle weakness (2-4). This may lead to physical inactivity and a sedentary lifestyle (4-6). With that decreased physical activity can lead to fatigue and depressive feelings and diminished quality of life (6-9).

The physical activity level is positively influenced by aerobic capacity (10-14). Aerobic capacity is the product of the capacity of the cardio respiratory system to supply oxygen and the capacity of the skeletal muscle to utilize oxygen (15). Patients who suffered a stroke often have decreased aerobic capacity, due to physical inactivity. In addition, a low physical activity level can also decrease aerobic capacity. Therefore, patients who had had a stroke suffer the risk of entering a vicious circle with negative effects on quality of life (7).

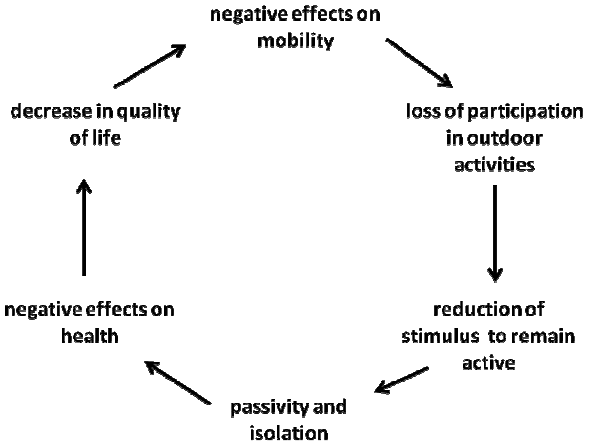

Figure 1. *Vicious circle of reduced mobility (7)*

Peak oxygen consumption (V_{O2}), the criterion measure for aerobic capacity, in patients who suffered a stroke, has been found to be as low as 50-70% of the age- and sex-matched value in sedentary people (16, 17). Therefore improving aerobic capacity should be one of the main goals in the rehabilitation program of a patient who suffered a stroke. However, the cardiovascular stress in current programs is often too low to induce a positive aerobic training effect (18).

The American College of Sports Medicine (ACSM) developed criteria (e.g. maximum heart rate) to determine maximum aerobic capacity in healthy subjects (15). However, these criteria are not suitable for patients who suffered a stroke, because of their physical impairments, such as spasticity, decreased blood flow in the hemiparetic limbs and comorbidity (19, 20). In addition, there is a lack of valid measuring instruments for determining maximum aerobic capacity in patients who suffered a stroke. Recent studies show high reproducibility in determining maximum aerobic capacity in patients who suffered a stroke (21-28). However, validity of the used measuring instruments was not examined.

At this moment there is no gold standard for determining maximum aerobic capacity in patients who suffered a stroke. Health professionals apply for adequate measuring instruments for determining maximum aerobic capacity that are applicable in stroke rehabilitation.

The six minute walk test (6 MWT) is often used for determining maximum aerobic capacity (29-32). However, there are disadvantages when used in patients who suffered a stroke. For example, due to the prescribed test duration patients are not provoked to exert themselves to a maximum level of aerobic capacity. Therefore it is likely that the 6 MWT often measures the submaximum level of aerobic capacity (29-32).

In order to achieve a maximum level of aerobic capacity Singh et al. developed a shuttle walk test (SWT) suitable for patients with chronic obstructive pulmonary diseases (COPD). Validity was assessed comparing the SWT and the 6 MWT and it was shown that the SWT provokes the patient to a maximum level of perceived exertion. Also, this study demonstrated good reliability for the SWT in patients with COPD (33). The SWT has also been examined in patients with chronic heart failure (34), patients with pacemakers (35), patients with chronic low back pain (36) and patients with polyneuropathy (37), in which good validity and reliability was established. Based on the same principals Verschuren et al. developed and validated a shuttle run test (SRT-II) with a modified protocol for children with cerebral palsy at Gross Motor Function Classification System (GMFCS) level II (38).

As mentioned above suffering from a stroke, just like suffering from COPD and cerebral palsy, may lead to chronic disabilities and (neurological) impairments (1). Therefore, the SWT and SRT-II may be applicable for measuring and evaluating maximum aerobic capacity in patients who suffered a stroke. The purpose of this

study is to examine the feasibility of the SWT and SRT-II for measuring and evaluating aerobic capacity in patients who suffered a stroke.

Methods

The study procedures were followed in accordance to institutional guidelines and were approved by the local university an hospital ethics committees. Written informed consent was obtained from all study participants. This cross-sectional study was part of a larger trial examining the validity and reproducibility of a shuttle walk test for measuring and evaluating aerobic capacity in patients who suffered a stroke.

Participants

Adult patients who suffered a stroke, according to the World Health Organization (39), were recruited from the St. Antonius Hospital Utrecht/Nieuwegein and Rehabilitation Centre De Hoogstraat, Utrecht, the Netherlands. Participants were informed by their physician or physiotherapist and received written information concerning the test and evaluation procedures. Both in- and outpatients participated in this study. To be included in the study, patients should be able to walk independently (Functional Ambulation Categories (FAC) ≥ 4), understand the test and evaluation procedures and provide written informed consent.

Participants were excluded if they had a score ≥ 3 on one of each of the first three items of the Cumulative Illness Rating Scale (CIRS). These items indicate comorbidity related to the cardio respiratory system. A score ≥ 3 indicates severe disorders which need immediate treatment. Participants were also excluded if they suffered from orthopedic, neurological (besides stroke) or vascular problems which would limit walking distance.

Measures and procedure

Participant demographic information, stroke lesion type and location, time post stroke, FAC score, possible walking aids and medication use were registered. The SWT and SRT-II were performed once with at least three hours in between and with practice tests beforehand to avoid a learning effect. The tests were performed with three patients at the same time. To avoid an order effect the order of testing was

varied. The first group of patients started with the SWT, followed by the SRT-II. The next group started with the SRT-II, followed by the SWT. Testing order was determined in this way, until fifteen patients performed both tests.

The SWT was conducted as described by Singh et al. (33) requiring patients to walk up and down a ten meter course marked out by two cones inset half a meter from either end to avoid abrupt changes in direction. The first speed level (0.50 m/s) is referred to as level one, the second (0.67 m/s) as level two and so on. There is a maximum of twelve progressive levels lasting one minute each. Each level consists of a number of shuttles, ranging from three shuttles in the first level to fourteen shuttles in the last level. One shuttle corresponds to a distance of ten meters and starts and ends with a bleep. The subject should aim to be at the opposite end of the ten meter course by the time the bleep sounds. After every minute, walking speed is increased by a small increment (0.17 m/s), so the subject walks progressively faster; this is indicated by a triple bleep.

The SRT-II was conducted as described by Verschuren et al. (38) requiring patients to walk up and down a ten meter course marked out by two cones inset half a meter from either end to avoid abrupt changes in direction. The first speed level (0.56 m/s) is referred to as level one, the second (0.63 m/s) as level two and so on. In the SRT-II it is also indicated when half of the level is reached, although walking speed does not increase. There is a maximum of 23 progressive levels lasting for about one minute each. Each level consists of a number of shuttles, ranging from three shuttles in the first level to twelve shuttles in the last level. One shuttle corresponds to a distance of ten meters and starts and ends with a bleep. The subject should aim to be at the opposite end by the time the bleep sounds. After every minute, walking speed is increased by a small increment (0.07 m/s), so the subject walks progressively faster; this is indicated by a double beep.

Both tests were ended when a. the patient was too tired to maintain the required speed, b. the patient twice failed to complete a shuttle in the time allowed or c. the assessor forced the participant to slow down due to increased risk of falling. Maximum level reached, distance covered in meters, test duration, heart rate, and perceived exertion using the Borg-scale (40) were measured at the end of the test. In this study the walking test that showed the highest heart rate at the end of the test was considered most feasible. The practical feasibility of both tests was also examined on aspects of safety, materials and time investment.

During both tests the author (MvhH) was assisted by two assessors (HvdS and EB). The author recorded the test results, while the assessors were present for safety reasons during the tests. Chairs were available for patients who needed a rest after the tests. Each individual wore a coded Polar heart rate monitor to record the heart rate achieved during each test. The heart rate of each individual was recorded directly after the test by the author. As both tests required the patients to increase their walking speed and aerobic capacity progressively to their maximum, the recorded heart rate at the end of the test probably matches the maximum heart rate of the patient. Perceived exertion, using the Borg-scale (40), maximum level reached, distance covered in meters and test duration were registered by the author directly at the end of the test.

Statistical Analysis

Data analysis was performed using SPSS Statistics, version 17.0. Means with standard deviations were calculated for distance, heart rate at the end of the test, test duration and perceived exertion in both tests. The concordance between the results of the tests was established by using dependent t-tests. Specifically heart rate at the end of the test, test duration and perceived exertion immediately after each test were compared. A p-value ≤ 0.05 was considered significant.

Results

Figure 2 shows the flow of participants through the study and allocation regarding the testing order. Fifteen patients were recruited from April till June 2009 and met the inclusion criteria.

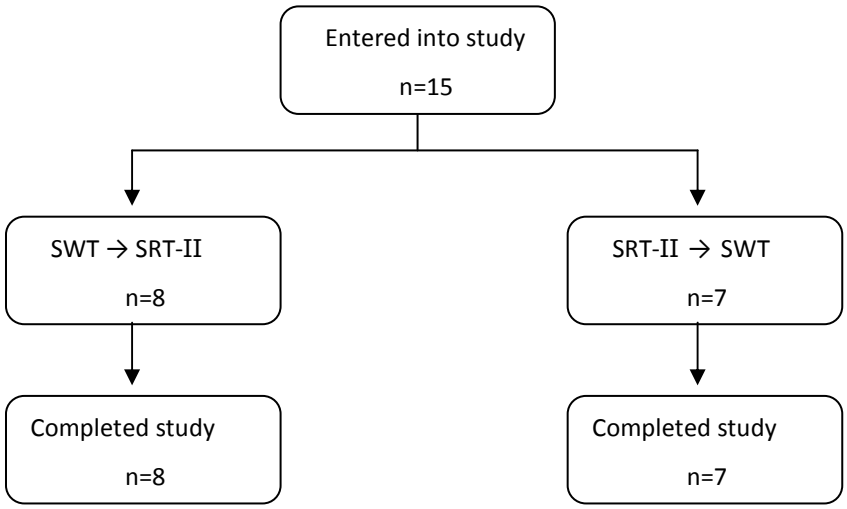

***Figure 2**. Flow of participants through the study*

Demographic characteristics are presented in table 1. Eight men and seven women entered the study. Mean age was 70 ± 6.1 years (range, 54-77). Time elapsed since they suffered a stroke was 60 ± 43.9 days (range, 7-184). An ischemic stroke was diagnosed in twelve patients and three patients suffered from a cerebral hemorrhage. Nine patients had had a stroke in the right hemisphere, six in the left hemisphere. There were four patients who required aids for ambulation (two walking sticks and two rolling walkers). Nine patients used antihypertensive medication (beta-blockers).

Table 1: *Participant characteristics*

	n	Mean ± SD (range)
Men/women	8/7	
Age, years		70 ± 6.1 (54-77)
Stroke type		
Ischemic/hemorrhagic	12/3	
Right/left hemisphere affected	9/6	
Time post stroke, days		60 ± 43.9 (7-184)
Body Mass Index		24,1 ± 2.3 (19.8-28.3)
Walking aid/no walking aid	4/11	
Functional Ambulation Categories		
score 4/score 5	10/5	4.3 ± 0.5 (4-5)
Beta blockers/no beta blockers	9/6	

Feasibility of the SWT and SRT-II

The SWT and SRT-II were performed on a ten meter course in a gym. The total distance that was needed to perform either the SWT or the SRT-II was twelve meters. Patients who used walking aids needed approximately one and a half meter behind the cones to turn around safely. The course was about three meters wide for each individual. Each test took on average about twenty minutes to execute, including instructions and was conducted with three patients in one group.

The SWT and SRT-II measure and evaluate aerobic capacity. In this study the feasibility of both tests is examined in patients who suffered a stroke. Results from the SWT and SRT-II are presented in table 2. All patients performed the SWT and the SRT-II and no individuals withdrew during the study. Three patients were not able to make it through the first level of both tests, due to their stroke-related impairments. The required walking speed was not reached and the assessor ended the test after 40 seconds. A total distance of 20 meters in both tests was walked by these three patients.

The average test duration of the SWT was 5 minutes and 57 seconds (357 ± 186 seconds, range 40-600) and of the SRT-II 7 minutes and 46 seconds (466 ± 251 seconds, range 40-798). A significant difference in test duration was found between

the SWT and SRT-II ($p < 0.001$). These data are based on all participants, including the three patients who were not able to make it through the first level of both tests. Significant differences were also found in heart rates immediately after the test in favor of the SRT-II ($p = 0.001$). The mean heart rate achieved at the end of the SWT was 112 beats per minute, against 120 beats per minute in the SRT-II. The average Borg-score in both tests was slightly over 17 points, which means in the case of physical activity a person can still go on, but he or she really has to push him- or herself. It feels very heavy, and the person is very tired. Although there were significant differences between the SWT and SRT-II regarding test duration and heart rates at the end of the test, no significant differences were found in Borg-scores of perceived exertion ($p = 0.395$).

Table 2: *Results from the SWT and the SRT-II*

	SWT [a]	**SRT-II** [a]	***p* value**
Test duration, seconds	357 ± 186 (40-600)	466 ± 251 (40-798)	< 0.001*
Distance, meters	370 ± 241 (20-750)	393 ± 242 (20-780)	< 0.001*
Heart rate, bpm	112 ± 19.2 (75-132)	120 ± 18.5 (87-138)	0.001*
Borg-score[b]	17.1 ± 2.0 (13-20)	17.5 ± 1.8 (15-20)	0.395

Abbreviations: SWT, Shuttle Walk Test; SRT-II, Shuttle Run Test for children with cerebral palsy at GMFCS level II, bpm, beats per minute

[a] Values are mean ± SD, range

[b] The Borg scale is a 15 point scale for scoring perceived exertion ranging from 6 to 20, where 6 means "no exertion at all" and 20 means "maximal exertion".

* significant difference in favor of SRT-II

Discussion

The early and significant deconditioning that occurs after stroke underscores the importance of establishing effective interventions to minimize the impact on long-term stroke recovery (17). These interventions should be based on adequate measures of

aerobic capacity, to obtain aerobic exercise programs with optimal effects on aerobic capacity.

In this study the SRT-II appears to be more feasible in patients who suffered a stroke than the SWT, based on the main outcome measures and practical feasibility. Significant differences were found in favor of the SRT-II in heart rate at the end of the test and in test duration. According to the author (MvhH) this is the first study that examines the feasibility of the SWT and the SRT-II in patients who had had a stroke for measuring and evaluating aerobic capacity.

According to Buchfuhrer et al. optimal time in which a subject achieves maximum exercise tolerance and aerobic capacity is between 8 and 17 minutes (41). In this study the average test duration of the SWT was about six minutes and the average test duration of the SRT-II was almost eight minutes. Therefore, it is likely that aerobic capacity in the SRT-II reaches a higher level compared to the SWT, due to the longer test duration.

It is difficult to compare the results of this study with previous studies that examined feasibility of a shuttle walk test in other patients, like patients with chronic heart failure (34), patients with pacemakers (35), patients with chronic low back pain (36) and patients with polyneuropathy (37). In these studies only Singh's protocol for the SWT (33) was used to examine feasibility in clinical practice. In the present study feasibility of two shuttle walk tests were compared and examined on their feasibility in clinical practice.

Maximum heart rate is often estimated using the age-predicted equation of 220 – age (15). Previous studies that examined the feasibility of the SWT in patients with chronic heart failure (34) and COPD (33) found average maximum heart rates of 86% and 82% of the predicted maximum heart rates, using this equation. In the present study the heart rate at the end of the test was 75% of the predicted maximum heart rate in the SWT and 80% in the SRT-II using this equation. These findings correspond to the results of Tanaka et al. who concluded that this equation is not validated for use in patients who suffered a stroke to determine the maximum heart rate (42). Another difficulty in determining maximum heart rate in patients who had had a stroke is that the majority of these patients use antihypertensive drugs (i.e. beta blockers), which affect the ability to achieve maximum heart rate (43, 44). In the present study the majority of the participants used beta blockers and this probably influenced the heart rates at the end of both tests. Still, this study showed significant

differences in favor of the SRT-II in heart rate at the end of the test which indicate that the SRT-II is more feasible for measuring aerobic capacity in patients who suffered a stroke than the SWT.

In the present study a significant difference was found in favor of the SRT-II in heart rate at the end of the test. Though it is likely that the patient's heart rate at the end of the test matches the maximum heart rate, it might be possible that during the test a higher heart rate level was achieved compared to the heart rate at the end of the test. No significant difference was found between the Borg-scores of perceived exertion. Two participants had problems in scoring perceived exertion, because they did not fully understand the purpose and execution of the Borg-scale. Although it appears that these participants scored perceived exertion from their objective and point of view in both tests, mean scores of the complete sample have been influenced by the Borg-scores of these patients as both patients applied significant lower Borg-scores than the other patients. In addition, there were two patients during the SWT and one during the SRT-II, who had to stop due to fatigue in the hemiparetic limb instead of maximum cardio respiratory performance. This probably influenced the mean main outcome scores in both tests. Nevertheless, if the results of these patients were excluded for data analysis, the significance of the differences found between the mean main outcome measures of both tests was not changed.

Three patients were not able to gain enough walking speed to make it through the first level of both tests. They were able to walk independently (FAC 4), but apparently it does not mean that walking speed is high enough to complete the first levels of the walk tests. In addition, mean gait speed of patients who suffered a stroke varies highly. In a community dwelling population reported speeds vary between 0.80 m/s (2.88 km/h) and 1.20 m/s (4.32 km/h) (45-47). Although the required walking speed in the present study is 0.50 m/s (1.8 km/h) for the SWT and 0.56 m/s (2.00 km/h) for the SRT-II, three patients were not able to make it through the first level of both tests. This might indicate that the SWT and the SRT-II are not useful to measure aerobic capacity in all patients who had had a stroke and are able to walk independently (FAC ≥ 4). Future research should focus on developing a shuttle walk test with a lower gait speed at the beginning of the test, which enables patients with lower gait speed to participate.

In addition, it appears that walking speed in the SWT increases too much for at least a part of the patients who suffered a stroke, compared to the SRT-II. In the SWT after

only three minutes a walking speed of 0.84 m/s (3.00 km/h) is required to proceed with the test, while this walking speed is required after five minutes in the SRT-II. Therefore, the participants could participate in the SRT-II for a longer time, compared to the SWT.

There are also some considerations to be made, regarding the practical feasibility of both tests. In the first place there was a large space required to set out the ten meter course. The total distance that was needed to perform either the SWT or SRT-II was about twelve meters. Patients who used walking aids needed this space to turn around the cones. The course was at least three meters wide, because of the chairs standing at both sides. According to the author (MvhH) the minimal length and width of the course should be as described above for practical use. However, less space was needed to perform both tests than the space needed in the 6 MWT, which has a recommended length of 30 meters (48). Another advantage of the SWT and the SRT-II is the possibility to perform the tests in a group, unlike the 6 MWT which is conducted individually.

Secondly, in most of the cases, it was needed that an assessor walked along with the patient, because of safety reasons. The risk of falling in the late stages of both tests increased too much to leave the patient unattended. However, no falls were reported during the walking tests. In addition, in this study the author (MvhH) was assisted by an assessor who walked along with the patient and could end the test when the risk of falling increased too much. Therefore, safety for the patients to exert themselves to a maximum level of aerobic capacity was reached. The author was able to record the results of the tests, without the concern to look after the patients safety. In practical use it might be a problem to combine the recording of the results and also to look after the patients safety.

Conclusion

From this study it can be concluded that the SRT-II is more feasible for measuring and evaluating aerobic capacity in patients who suffered a stroke than the SWT. However, future research should focus on examining feasibility and validity of a shuttle walk test with a lower walking speed at the beginning of the test, which enables patients with lower walking speed to participate.

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