Abstract

Objectives: to evaluate the feasibility and usability of the Senior Fitness Test (SFT) in persons with acquired brain injury.

Methods: A pilot cohort design with a convenience sample of persons with acquired brain injury.

Results: Persons with acquired brain injuries [n=47] were younger than their healthy counterparts [n=172] were but performed significantly worse on sit to stand, 6 Minute –Walk-Test (6MWT) and 2.45m up-and-go. This difference was accentuated in the age groups > 60 years of age. Persons with acquired brain injuries, divided into subgroups Traumatic Brain Injury (TBI) [n=12] and Cerebral Insult (CI) [n=35], showed significant differences in leg strength, upper extremity flexibility and walking capacity. Persons with CI were weaker, less flexible in upper and lower extremities, walked shorter distance and were less mobile. CI but not TBI performed significantly worse when compared to healthy elderly persons.

Conclusion: This study indicates that SFT is feasible, safe and useful tool for persons with acquired brain injury, to evaluate physical capacity, endurance, strength and flexibility. The sub maximal test was well tolerated and could be performed by all participants irrespective of age or diagnosis. The distribution of test scores indicates responsiveness to change, and no ceiling or floor effects.

Keywords: acquired brain injury, cerebral insult, senior fitness test, traumatic brain injury

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Senior Fitness Test; a useful tool to measure physical fitness in persons with acquired brain injury

Introduction

Physical activity levels are closely related to health and are important to maintain [1]. Lifestyle, lifestyle diseases, or physical inactivity [2-4] may cause acquired brain injury. A long hospitalization may enhance an inactive lifestyle and persons with acquired brain injury resulting in reduced physical fitness as a secondary complication after the acquired brain injury [5-6].

Acquired brain injury (ABI) includes traumatic brain injury (TBI) and non-traumatic brain injuries. TBI´s may be contact, referring to a direct external trauma to the head, or non-contact injuries, referring to acceleration or de-acceleration forces which make the brain move inside the skull causing damage to the same. Non-traumatic brain injuries on the other hand refers to an internal insult, as for example the rupture of a blood vessel causing an internal hemorrhage, or a reduction in blood flow due to clotting, causing brain injury [7].

A minimum level of fitness is a prerequisite to maintain health, activities of daily life and health related quality of life [1]. However, physical fitness after acquired brain injury is not evaluated in the hospitals, so little is known of how primary and secondary influences interact. Maximal endurance or strength is rarely tested in persons with brain injury, because of the risk for complications. A simple submaximal tool, in acute and post-acute clinical care, to evaluate physical form such as strength, endurance, flexibility and balance would therefore be of value.

The Senior Fitness test [SFT] is a test kit consisting of submaximal tests of endurance, strength and flexibility [8]. SFT is used to evaluate physical fitness mainly in older people [9-15], and but has not been used in persons with brain injury. However, some of the items, like 6-Minute-Walk-Test

[6MWT] and Timed-Up-and-Go [TUG], are frequently used in clinical evaluations of people with acquired brain injuries by physiotherapists. It is therefore reasonable to assume that the total SFT may be a useful screening tool to evaluate the submaximal physical fitness in persons with acquired brain injury, both in acute and post-acute care. The information would be vital in the evaluation and goal settings for persons with acquired brain injury.

The purpose with this study was to evaluate the feasibility of the SFT in persons with acquired brain injury, to evaluate the usability during post-acute rehabilitation and in municipality services. In addition, we wanted to compare the test results in the persons with acquired brain injury, to the results in healthy counterparts. Thus, we would study to what degree physical fitness is reduced in persons with acquired brain injury compared to the physical fitness in a control group and possibly establish norm values for this group.

Methods

A pilot cohort design with a convenience sample of persons with acquired brain injury. Persons with acquired brain injury were invited, consecutively recruited, and tested in two different settings: at the specialized rehabilitation unit and in community rehabilitation services. Healthy counterparts were recruited from an urban community through advertising. The same experienced person tested all participants in their respective unit.

Ethics

All participants received verbal and written information about the purpose before the testing, and signed a written consent of voluntary participation. The project was reported to the Norwegian Center for Research Data, reference number 21106/1.

Subjects

Persons with TBI were recruited from the specialized rehabilitation unit, where they met for a 6 months evaluation post injury. The persons with TBI had a mild-moderate disability, with a BI mean

20, range 20-20, and mainly with cognitive deficits. Persons with CI were recruited from the acute hospital, community based services, and specialized rehabilitation, 2 months to 1-year post stroke. They had a mixture of physical and cognitive disability with a BI mean 17.9, range 3-20 (Table 1).

Outcome measure

The participants are described by age and gender. In addition, activities of daily living (ADL), the presence of cognitive deficits and pain were registered. Cognitive deficits were categorized into intact / reduced, and pain into present or not. Heart rate was registered when performing 6MWT in persons with acquired brain injury.

Senior Fitness Test

The SFT, developed by Rikli & Jones in the US for adults 60+ [8], has been translated into Danish, and this was the version used in this study (9).The SFT is simple to use, it does not require expensive tools or technical expertise, and may be performed in the usual, well-known surroundings. The test consists of six functional measures of strength in arms and legs, endurance, balance, agility and flexibility, and it takes approximately 30–40 minutes to perform. The items are shortly described:

- Chair stand in 30 seconds to measure lower-body strength
- Arm curl to measure upper-body strength; number of biceps curls completed in 30s. The original weights were 5lb [2.27kg] for women and 8lb [3.63kg] for men.
- 6-Minute Walk Test (6MWT) to assess aerobic endurance; distance walked in m. In the original study this was performed in a rectangular shape, divided into 5 yards length measuring a total of 50 yards [45.7m].
- 2-minute step test to assess aerobic endurance, the number of full steps completed in 2 minutes;
- Chair-sit-and-reach test, cm to assess lower-body flexibility;
- Back scratch test, cm to measure upper-body flexibility;

- 2.45 meter up-and-go test, sec to assess agility and dynamic balance;
- Body Mass Index [BMI] [weight/height^2].

The SFT is tested for reliability, with an ICC [Intra Class Correlation coefficient] ranging from 0.8 to 0.98 on the different items [10-13]. Validity of the different items was tested to a “gold standard”, like, for example, chair stand versus one repetition maximum [RM] leg press; arm curl versus combined 1RM biceps, chest and upper back [10]. The association between the gold standard and the items in The SFT ranged from 0.73 to 0.83. However, there is no gold standard or direct criterion for two of the items, namely in 2.45m up-and-go and back scratch [10-11].

The SFT version was modified and adapted to the Norwegian metric and weight system in items the biceps curl test, the 6MWT and the flexibility test. Normative standards for healthy elderlies exists, confirming comparable normative results between healthy elderly people in the USA and Norway [8-9, 15].

Barthel Index

Barthel Index [BI] is a test of primary activities of daily living [ADL] developed by Mahoney and Barthel [16] for measuring functional independence in personal care and mobility. The BI version with a maximum of 20 points was used.

Pulse

Heart rate was measured with a pulse monitor, Sport tester™ PE 3000, made by Polar Electro, Finland. In a smaller sample of the subgroups of persons with acquired brain injury pulse in activity was recorded during the 6MWT. The mean of three measurements of the highest pulse rates was recorded.

Statistical analysis

The statistical analyses performed with the SPSS package for Windows, version 24 [SPSS Inc. Chicago IL]. Standard descriptive statistics mean [SD] and frequencies were used to describe the sample as a whole and subgroups. Possible ceiling and floor effects were evaluated by looking at the distribution of responses and from reported skewness and kurtosis of the different items of SFT.

A comparison between the samples acquired brain injury and a normative sample of healthy elderly, was performed with an analysis of variance [ANOVA], as well as sub group analysis. In these sub-group analysis additional associations with cognitive function and intensity/pulse was evaluated with Spearman correlations.

A linear regression analysis evaluating explanatory factors was performed where the items of SFT were consecutively inserted as dependent variables and age, pulse, level of independence in ADL [BI] cognitive function, and subgroups TBI and CI were inserted as independent variables. A p value <0.05 was set as significant.

Results

In total 47 persons with acquired brain injury participated in this study, of these 12 had Traumatic Brain Injury [TBI] and 35 Cerebral Insult [CI]. In addition, 172 healthy elderly from the earlier SFT study was used to evaluate normative values for SFT.

Description

Persons with acquired brain injuries were younger and with more males than their healthy counterparts. Furthermore, they were dependent in ADL, had more pain and presented with reduced cognitive function compared to the healthy counter parts [Table 1].

Divided into sub-groups, persons with CI were significantly older than persons with TBI, 65 years versus 28 years, had multi-morbidities [n=15], reported a higher degree pain [n=6], and were less mobile [Table 1-2]. Males were predominant in the group with TBI [11 / 1] compared to the group with CI [22 / 13]. Multi-morbidity was presented as mainly a combination of high blood pressure, heart disease and lung disease, in the group of CI. Persons with TBI had mainly muscle and skeletal problems.

Independence in ADL but reduced cognitive function was registered in all persons with TBI (Table 1). In persons with CI, on the other hand, 50% had a reduced cognitive function and participants were to a higher degree dependent in ADL [Table 1].

A subgroup of persons with CI [n=9] and TBI [n=8] displayed equal pulse peaks in relation to the performance of 6MWT [Table 2], indicating that the performance was on a moderate to high intensity. Estimated maximal pulse rate [31] indicated that persons with TBI had an intensity of 69% of their maximal pulse versus 78% in persons with CI during walking.

No floor and ceiling effects of SFT in the different groups could be noted. The distribution of scores were even, skewness and kurtosis ranging between -0.3 to 1.3 and 0.06 to -1.2 respectively.

Group differences in Senior Fitness Test

Persons with acquired brain injuries were younger than their healthy counterparts were but performed significantly worse on sit to stand, 6MWT and 2.45m up-and-go [Table 29. This difference was accentuated in the age groups > 60 years of age [Table 3]. Persons with acquired brain injuries, divided into subgroups TBI and CI, showed significant differences in leg strength, upper extremity flexibility and walking capacity [Table 2]. Persons with CI were weaker, less flexible in upper and lower extremities, walked shorter distance and were less mobile. CI but not TBI performed significantly worse when compared to healthy elderly persons [Table 2].

The items sit to stand, 6MWT, 2.45 up-and-go and back scratch had a medium non-significant association, r= 0.3 to 0.4, with intensity /pulse, whereas cognitive function had a small but significant association, r=0.2, with back scratch and chair sit and reach.

The linear regression analysis of the different items SFT as independent variables and acquired brain injury, age, BI and cognition as independent was a significant model for three items: endurance, mobility and strength. For endurance, estimated with the 6MWT, main explanatory contributors were age [B= -1.93, p= 0.07], cognition [B= 131.25, p= 0.0001] and BI [B= 41.75, p=0.00019], explaining 95%. For mobility, estimated with 2.45 up-and-go, main explanatory contributor was age [B=0.14, p=0.03] explaining 51%. Finally for strength, estimated with sit to stand, main contributors were BI [B=0.91, p=0.0001] and age [B= -0.09, p=0.04] explaining 60%.

The items responsiveness was evaluated in a smaller sample recruited from the rehabilitation unit. The persons with acquired brain injury in this group experienced less physical disability (BI=20) and their SFT scores at baseline (for example 6MWT: 765m / 577m, 2.45 up and go: 3.4 / 5.9) were in general better, independent of TBI or CI. The results in this small subgroup indicate change independent of age [Table 4].

Discussion

This study indicates that SFT is feasible, safe and may be considered a useful tool for persons with acquired brain injury in both specialist and community based rehabilitation, to evaluate physical capacity, endurance, strength and flexibility. The sub maximal test was well tolerated and could be performed by all participants irrespective of age or institution. The distribution of test scores indicates responsiveness to change, and no ceiling or floor effects.

The test results indicate a lower performance in persons with acquired brain injury compared to a healthy group of elderly. However, sub-group analysis indicated that persons with CI performed significantly poorer on most items, except arm curl, versus persons with TBI and healthy counterparts [Table 2]. Persons with TBI had a similar and even better physical capacity than the healthy elderly. The results are in line with other studies indicating poor physical capacity in persons with CI compared to healthy counterparts [17-18].

The difference between persons with TBI and CI was not expected, but there may be several explanations to this difference; one is age and disability / dependence in ADL, which were explanatory factors in the models for endurance and mobility. The accumulation of multi-morbidities before debut of CI is another, influencing both physical capacity and physical activity patterns in a negative way [19-20]. In addition, inactivity patterns have been shown to be enhanced in acute care, which may continue the negative development regarding dependence in ADL and reduced physical capacity [5-6]. Fear that activity might provoke a new stroke may also be related to the inactivity patterns, as well as physiological explanations to the decreased activity patterns related to cardiac reserves and muscle metabolism [21-22]. Persons with TBI, on the other hand, had few or no pre morbidities and were young and active persons before their trauma in this study [Table1]. Many of the participants with TBI exercised on a relatively high level, and the reason for rehabilitation was mainly cognitive deficits [Table 1].

Multi-morbidity, a combination of high blood pressure, heart disease and lung disease, alternatively muscle and skeletal problems, were similar in persons with acquired brain injury and healthy counterparts, although age dependent, so that with increasing age more multi morbidities [23]. However, there was less morbidities in the TBI group than in the CI and healthy elderly persons groups [Table 1].

The fact that TBI and a healthy population of elderly had the same results may be explained by the cognitive deficit persons with TBI presented. This deficit may influence physical performance and explain why reasonably fit younger persons perform on equal level as their healthy elderlies. From this perspective, persons with TBI performed reasonably well in view of a serious trauma and cognitive deficits [23]. Healthy counterparts' reasonably good performance despite ageing and multi-morbidities indicates that this group of elderly maintained their function, indicating an active life style. The results verifies CI as a serious disease / trauma with high risk of disability irrespective of age leading to inactivity [19].

Persons with CI used more energy in order to perform the 6MWT than persons with TBI, underlining the difference between the two sub-groups related to endurance. However, both CI and TBI used reasonably high effort in performing the test and when looking at the whole sample acquired brain injuries [Table 1]. Disability rather than an age seem to explain reduced performance > 70 years of age [9, 11, 15].

The results of this small study must be interpreted with caution. There were difficulties in recruiting volunteers for testing in the clinic, indicating problems with transport back and forth from home. Participation in activities and training outside the home may be perceived as a huge barrier for persons with acquired brain injury [31]. The persons who were positive to participate in this study may have been less physically disabled than a general population of persons with brain injury. On the other hand, cognitive decline was present in a majority of participants, which indicates that SFT is both feasible and useful for persons with cognitive decline.

Conclusion

The Senior Fitness Test is a sub maximal test kit for physical fitness. It is simple to use in the clinical setting and has no floor or ceiling effect. The SFT is also sensitive / responsive for changes in persons with acquired brain injury. The test results underline SFT´s usefulness, not only in the elderly population but also in CI- and the younger Traumatic Brain injury patients.

Declaration of interest

The authors report no declarations of interest

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Table 1 Description of participants: Acquired brain injury, divided into TBI / stroke and healthy counterparts.

	AQUIRED BRAIN INJURY (n=47)	TRAUMATIC BRIAN INJURY (n=12)	STROKE (n=35)	HEALTHY ELDERLY (n=172)
AGE (years)	55 (29.5)	28 (11.8)	65 (16.4)	73 (5.8)
HEIGTH /WEIGHT (m/kg)	177.7 (7.7)/ 80.7 (10.6)	181.5(7) / 81.3 (10.2)	175.5(7.5) / 80.3(11.2)	168.6 (8.4) / 70.4 (12.0)
BMI	25.4(3.6)	24.0(2.8)	25.9(3.8)	24.6(3.2)
MALE	33 (70.2%)	11 (92%)	22 (63%)	48 (28%)
BARTHEL INDEX	18.4 (4.1)	20 (0)	18 (4.5)	20 (0)
PAIN (n, present)	6 (13%)	0	6 (17%)	-
PULSE	128 (29.5)	130 (32.7)	126 (28.1)	-
COGNITION (n, reduced)	30 (64%)	12 (100%)	18 (51%)	0
MULTIMORBIDITY (n)	18 (38%)	3 (25%)	15 (43%)	103 (60%)

Table 2 Test results of the different items of the Senior Fitness Test in the three groups: Traumatic Brain Injury (TBI), stroke and Healthy Elderly presented I mean scores, SD and p-values set at p<0.05.

SENIOR FITNESS TEST:	TBI (n=12)	STROKE (n=35)	p-value	HEALTHY ELDERLY (n=172)	p-value
SIT TO STAND (n; in 30s)	17.6 (4.6)	11.9 (6.5)	0.01	15.8 (5.1)	0.09
ARM CURL (n; in 30s)	16.8 (7.0)	16.3 (7.8)	0.8	15.2 (3.7)	0.001
2.45M UP AND GO (s)	4.7 (1.3)	8.6 (7.7)	0.09	5.0 (1.2)	0.001
LOWER EXTREMITY FLEX (cm)	-3.3 (12.2)	-7.3 (13.0)	0.2	2.7 (12.3)	0.001
UPPER EXTREMITY FLEX (cm)	-7.0 (8.9)	-15.8 (11.9)	0.03	-4.3 (10.1)	0.001
6 MWT (m)	676.3 (76.0)	439.3 (224.1)	0.001	598.3 (93.4)	0.01
2 MIN HIP FLEX (n)	-	94 (58.4)	-	95.6 (22.0)	0.2
BMI	24.0 (2.8)	25.9 (3.8)	0.12	24.6 (3.2)	0.001

Table 3 Senior Fitness Test in groups' acquired brain injury and healthy elderly divided into age

	AQUIRED BRAIN INJURY					HEALTHY ELDERLY[1]					P-VALUES
	0-59 yrs (n=23)	60-69 yrs (n=7)	70-79 yrs (n=9)	80-89 yrs (n=6)	>90 yrs (n=2)	0-59 years	60-69 yrs (n=55)	70-79 yrs (n= 96)	80-89 yrs (n=21)	>90 yrs	
CHAIR STAND	17.2 (14.2)	12.7 (2.3)	8.1 (5.8)	10.7 (7.3)	4.0 (0)	-	15.7 (5.0)	16.5 (5.3)	13.1 (2.7)	-	0.002
ARM CURL	16.3 (8.1)	19.0 (7.9)	13.8 (5.6)	19.3 (8.3)	12.6 (2.5)	-	15.5 (4.3)	*15.4 (3.5)*	*13.5 (2.5)*	-	0.38
6MWT	639 (88.4)	544 (54.1)	314 (224.6)	370 (316.2)	50.5 (71.4)	-	612 (88.6)	604.4 (81.1)	535.0 (130.9)	-	0.001
2MST	159 (73.5)	95.0 (21.2)	43.0 (60.8)	79.0 (14.1)	-	-	99.9 (23.2)	96.2 (20.2)	81.3 (22.1)	-	0.001
CHAIR SIT AND REACH	-5.9 (14.1)	-6.6 (11.7)	-10.2 (13.0)	-3.3 (9.4)	7.0	-	2.9 (12.2)	3.6 (12.8)	-1.9 (9.9)	-	0.83
BACK SCRATCH	-9.7 (9.4)	-10.4 (7.6)	-21.5 (13.9)	-18.8 (16.3)	-17.0	-	-2.8 (8.9)	-4.5 (10.5)	-7.4 (11.4)	-	0.67
2.45M UP-AND-GO	4.9 (1.2)	5.8 (1.8)	12.9 (10.3)	7.7 (2.2)	34.0	-	4.8 (1.2)	5.0 (1.0)	5.8 (1.4)	-	0.001
BMI	25.2 (3.8)	25.3 (2.9)	25.6 (4.4)	25.2 (3.4)	25.0	-	24.7 (3.4)	24.7 (3.2)	24.2 (2.1)	-	0.15

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Table 4 Change scores on the items of the Senior Fitness Test (SFT) in persons with Traumatic Brain Injury (TBI), and persons with stroke before and after a training episode, mean scores (SD).

SENIOR FITNESS TEST:	TBI TEST 1 (n=12)	TBI TEST 2 (n= 3)	STROKE TEST 1 (n=35)	STROKE TEST 2 (n= 10)
SIT TO STAND (n, in 30s)	17.4 (4.7)	23.7(1.2)	11.9 (6.5)	16.6 (3.5)
ARM CURL (n, in 30s)	17.1 (7.3)	23.7 (7.4)	16.3 (7.8)	16.0 (3.1)
2.45M UP AND GO (s)	4.6 (1.3)	3.2 (0.4)	8.6 (7.7)	4.9 (0.8)
LOWER EXTREMITY FLEX (cm)	-1.3 (10.5)	-1.8 (11.8)	-7.3 (13.0)	-11.1 (16.5)
UPPER EXTREMITY FLEX (cm)	-7.2 (9.4)	4.7 (4.7)	-15.8 (11.9)	-14.9 (8.9)
6 MWT	682.5 (76.5)	789.3 (52.9)	439.3 (224.1)	628.1 (56.5)
BMI	24.5 (2.5)	25 (-)	25.9 (3.8)	26.0 (3.6)