Case studies to demonstrate the range of applications of the Southampton Hand Assessment Procedure

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Hand, functional assessment, prosthetics, function, compensatory motion, motion analysis, implant.

The Southampton Hand Assessment Procedure (SHAP) was devised to assess quantitatively the functional range of injured and healthy adult hands. It was designed to be a practical tool for use in a busy clinical setting; thus, it was made simple to use and easy to interpret. This paper describes four examples of its use: before and after a surgical procedure, to observe the impact of an injury, use with prostheses, and during recovery following a fracture. The cases show that the SHAP is capable of monitoring progress and recovery, identifying functional abilities in prosthetic hands and comparing the capabilities of different groups of injuries.

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Introduction

Background to the design of the procedure

The Southampton Hand Assessment Procedure (SHAP) is designed to measure a hand's functional range. A study of existing assessment techniques showed that, although such methods were statistically and clinically valid, they generally took too long to be practical clinically (Stanley and Tribuzi 1992). Unverified modification of existing assessments was found to be common (Light et al 1999, Light 2000). This practice compromises the original validity.

The study also showed that there was little consistency in the assessment of prosthetic hands and the lack of a measure of the effectiveness of a design made it difficult to compare the designs of prosthesis mechanisms or controllers. It is essential for stakeholders (prosthesis users, occupational therapists, prosthetists, funders of prosthetic provision and prosthetics researchers) to be able to contrast a current design with innovations.

A tool was therefore devised that was simple to administer and it was packaged to make application practical. It combines repeatable tasks into a procedure that can be completed in roughly 20 minutes. The numerical results simplify interpretation (Light et al 2002). The score relates to the performance of different grasp types, identifies which grasps are most affected, and allows assessment of prostheses and impaired hands.

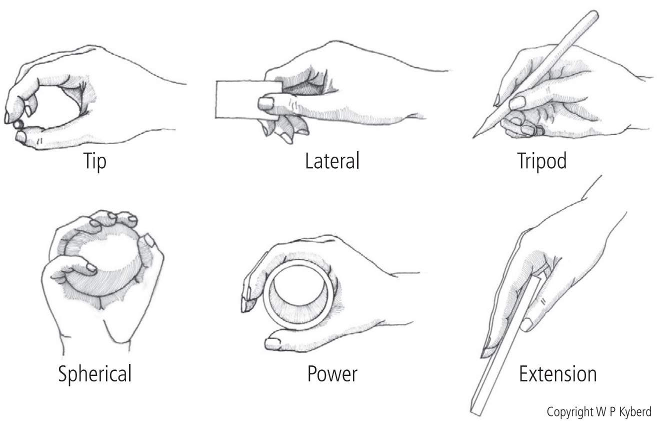
For details of the design and validation on an unimpaired population, see Light et al (1999, 2002) and Light (2000).

The SHAP procedure

The test uses a form-board and self-timed tasks (the participant starting and stopping the timer with the hand under test), which are divided into two sections: abstract objects and simulated activities of daily living (ADLs).

The abstract objects are shaped to encourage the use of six standard prehensile patterns (Fig. 1, Napier 1956, Kamakura et al 1980, MacKenzie and Iberall 1994) and of two different weights to test the participant's ability to form more powerful grips.

Fig. 1. Six grip classifications used in Southampton Hand Assessment Procedure assessment (Copyright W P Kyberd).



Fourteen simulated ADLs were selected for their repeatability from Sollerman (Sollerman and Sperling 1978). The activities include cutting, pouring, lifting and transferring loads (see Table 1). Each task is self-timed, because reaction time depends on both assessor and participant and it has been known to affect the standardisation of other assessment procedures adversely (Potvin et al 1972). In addition, SHAP gives an *objective* score of function (based on duration) and does not require the observational skills of the tester.

Table 1. Activities of daily living used in the Southampton Hand Assessment Procedure test (Light 2000)

Task	'Natural' grip classification
Pick up coins	Tip
Undo buttons	Tip/Tripod
Food cutting	Tripod/Power
Page turning	Extension
Remove jar lid	Spherical
Pour water from jug	Lateral
Pour water from carton	Spherical
Move a full jar	Power
Move an empty tin	Power
Move a tray	Lateral/Extension
Rotate a key 90°	Tip/Lateral
Open/close a zip	Tip/Lateral
Rotate a screw 90°	Power
Rotate a door handle	Power

An index of functionality is derived by calculating the straight line distance from the measured value to a set of standard times for a normal population for the same activity (Light et al 2002). Thus, the individual time is expressed in the context of the normal population and each grip type is therefore scored out of 100; this creates a functionality profile. The scores for the different grips then contribute to the overall score in proportion to their use in daily activities, as measured by Sollerman (Sollerman and Ejeskär 1995). The measured values are combined by the use of a weighted sum so that, as the Power grip is used 25% of the time, the overall score reflects that the Power grip contributes a quarter of its value to the overall score and the Extension grip only 10%. The result is then expressed as out of 100. Above 95 is in the normal range and lower scores relate to decreasing levels of function. In the analysis of the results, both types of score can be quoted.

Interpreting change

According to Beckerman et al (2001) and de Vet et al (2001), the *smallest real difference* (SRD) gives a measure of how much the score has to change for the difference to be greater than the normal variation in the data and so to be a statistically significant different measure. An observed change of greater than this size implies that it is a real change with 95% confidence:

Smallest real difference = 1.96*standard deviation of repeated measures.

For SHAP, the SRD was calculated from the overall score of the normative group. In this case the SRD is 2.0, so the overall score has to change by at least 2 for it to be *statistically* significant. This does not assume that the scores are distinct *clinically*, but this assertion is supported by the observation that scores for normal participants differ by less than three on repeated measures.

Aim

This paper aims to extend the knowledge of the test by demonstrating its applicability, through case studies.

The cases were chosen to show the ability (i) to measure the performance of different prosthesis types, (ii) to observe the impact of an injury and (iii) to monitor progress and assess the level of a disability.

Method

Ethical approval

The approval for the experiments was granted by local ethics committees.[1] The use of SHAP was part of larger experimental designs. The details supplied herein are only those that relate to the use of SHAP and readers are referred to the literature for other details.

Cases

The participants were divided into three groups:

A – Single assessments of people with various injuries to the hand and wrist (A1-A9)

P – Single assessments of different prosthesis users (P1-P8)

M – Monitoring of the progress following an intervention (M1 and M2).

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Table 2. Details of the injuries of the hand and wrist

Participant	Age (years)	Gender	Hand tested (dominant)	Time since injury (months)	Description of injury
A1	65	F	R (R)		Rheumatoid arthritis, all digits
A2	24	F	R (R)		Traumatic loss of middle and distal phalanges, digits 3, 4 and 5
A3	54	M	R (L)		Traumatic loss of middle and distal phalanges of all digits; reduced range of motion
A4	52	F	R (L)		Extensor tendon grafts in 3, 4, 5
A5	19	F	R (L)	7	DRF, extra-articular with dorsal cortex comminution and no radial shortening; apex volar angulation 30°
A6	62	F	R (R)	6	DRF, intra-articular with dorsal cortex comminution and radial shortening; apex volar angulation 25°
A7	24	F	R (R)	2	DRF, extra-articular with minimum dorsal cortex comminution and no radial shortening; apex volar angulation 35°
A8	36	F	L (R)	5	DRF, intra-articular with dorsal cortex comminution and no radial shortening; apex volar angulation 25°
A9	30	M	R (R)	2	DRF, intra-articular with dorsal cortex comminution and radial shortening, displaced dorsally; apex volar angulation 25°

DRF = Distal radial fracture. DRF patients: average age 34.2 years (standard deviation 16.8 years).

Table 3. Results of the use of the Southampton Hand Assessment Procedure on individuals with differing hand injuries, revealing differences in ability between participants with similar injuries

	Hand aetiology				Wrist fractures				
	A1	A2	A3	A4	A5	A6	A7	A8	A9
Overall	**84**	**94**	**77**	**84**	**89**	**92**	98	**93**	96
Spherical	**82**	**95**	**86**	**90**	**87**	**91**	**93**	**93**	96
Tripod	**83**	**86**	**67**	**52**	**86**	**91**	**95**	**91**	96
Power	**86**	**87**	**79**	**56**	**88**	**94**	96	**91**	97
Lateral	**85**	96	**60**	**91**	**91**	**93**	96	96	**95**
Tip	**87**	**95**	**77**	**92**	**91**	**91**	96	**89**	**93**
Extension	**82**	**94**	**82**	**71**	**93**	**93**	98	**93**	96

Scores outside the normal range are in **bold**.

Single assessments

This is a selection of assessments of impairments of the hand and wrist, which aims to demonstrate the test's range. The description of the injuries is reported in Table 2 and the results in Table 3.

Participants A1 to A4, Single cases

Participant A1 was slower than normal participants. She was observed to have a limited range of motion (RoM), which resulted in reduced scores for the Spherical, Tripod and Extension grips, which specifically test the joint RoM and strength.

Participant A2 lacked length in fingers 3 to 5. The grips that employ these fingers (Tripod and Power) score 5 to 10 lower than other grips, demonstrating that the test is sensitive enough to show this. The absence of the fourth and fifth digits affected the strength of the Power grip. The value of 94 for Extension suggests good adaptation of the use of the index finger and thumb.

For participant A3, the length discrepancy affects the tri-digit prehension. The absence of the thumb also hampered the ability to perform the Lateral grip against the radial side of the index finger, leading to the reduction in the score.

Participant A4 had grafts that limited the stability and RoM at the wrist, which affect Tripod and Power adversely. There was reduced strength and mobility of the fourth and fifth fingers, affecting Extension.

Participants A5 to A9, Distal radial fracture

Distal radial fractures (DRF) of the wrist were chosen because of the localised nature of the injury, and the essential role that the wrist plays in most activities. The treatment of DRF depends on the mechanism of injury (whether through shear or compression forces) and severity (determined by the involvement of the articular surface, the presence of comminution and/or the presence of radial shortening [Jupiter 1997]). Traumas involving the articular surface are considered more severe.

Conventional assessment of outcomes is often restricted to measuring the limitations of angular ranges and grip strength (Nakata et al 1985, Kopylov et al 1993, Trumble et al 1994). RoM and grip strength are on average 80% and 70% respectively of the contralateral side. There is less published information on the loss of functionality but, using the above measures and questionnaires, functional loss after injury was found to be positively correlated with fracture instability (Lindau et al 2000).

Characteristics

Five participants (A5-A9) underwent treatment for DRF and were tested using SHAP. The participants required percutaneous pinning and immobilisation for 6 weeks. Stabilisation occurred a maximum of one day after injury (Table 2).

SHAP results

Participants A5, A6 and A8 scored lower than the threshold (95), with lower subscores related to Tripod and Power (Table 3). Participants A5 and A7 had a better long-term prognosis because the articular surfaces were not involved. This shows a limitation of the use of SHAP alone. The test is based on the time to complete the tasks. Participants A7 and A9 were able to complete the tasks quickly, but with significant compensatory movements. In these participants, shoulder and elbow compensations were observed as the result of restricted wrist movements by a more detailed kinematic analysis (Murgia and Kyberd 2004, Murgia et al 2005a). For the other participants, the limited movements were reflected in lower SHAP scores, because the participants took longer to perform the tasks required.

Prosthesis users

Eight users of electrically driven prostheses were recruited (P1-P8, Table 4). In all eight, the myoelectric signals were used in a voluntary opening, voluntary closing format. The mechanisms were anthropomorphic, set in a Tip grip. Each used a self-suspending socket. Three possessed powered wrists under voluntary control and the others passive rotation. Control of the wrist was via a switch triggered by the increased rate of contraction of the command muscles.

The speed of operation was dependent on a number of factors specific to the fitting, including the command format and the type of battery. The hands were of the same type (Otto Bock), although P1 to P3 had the larger hands (7.25″) and the others the smaller (6.25″). For comparison an eighth hand, produced by Centri and of a similar size to the the other hands, was also assessed.

SHAP results

One purpose of any assessment system is to assist in the observation of those being studied (Table 4). It was clear that those with powered wrists often did not use them during prehension. When scores were compared, there was no significant difference between the two groups: mean overall scores, powered: 62 ± 16.4, unpowered: 42 ± 28.7 (p = 0.30, Student's t-test with unequal means).

Table 4. Results of using the Southampton Hand Assessment Procedure with anthropomorphic prostheses

Category	**Otto Bock (7.25″)**				**Otto Bock (6.25″)**			**Centri**
Participant	**P1**	**P2+**	**P3+**	**P4**	**P5+**	**P6**	**P7**	**P8**
Gender	M	M	M	M	F	M	F	F
Side	L	R	R	R	L	L	L	R
Overall	**80**	**66**	**76**	**48**	**44**	**17**	**23**	**43**
Spherical	84	75	85	79	37	23	32	55
Tripod	76	72	68	43	26	13	26	37
Power	78	47	71	55	30	15	24	27
Lateral	75	69	83	53	60	17	17	38
Tip	69	32	72	19	48	16	18	34
Extension	87	63	75	61	54	22	25	56

A cross [+] indicates if the prosthesis used a powered wrist.

By comparison, the difference between the smaller and larger hands was significant (p = 0.02): large 68 ± 14.3, small 28 ± 14.2. This suggests that the hand size is more important to the functional capabilities.

All these devices are set in the Tip grip. However, the scores for this grip are lower. To study this effect in more detail, the scores for each of the grips, relative to the overall rating, were calculated, by dividing the grip scores by the overall score (known as *normalising*). Thus, if any grip score is the same as the overall, it becomes one. If the prostheses are *more* functional, the score will be above one; less than one means a lower rating. This emphasises the *relative* performances. It shows that, although the hands are set in a Tip grip, these are the poorest in application (Fig. 2).

Progress monitoring

This shows two participants studied over time, with SHAP being used on a test/re-test basis. The first was used throughout an experimental intervention and the second was used during recovery from an injury.

Participant M1

A 48-year-old man had a neural implant inserted into the median nerve at the wrist of his left (non-dominant) arm. It remained in place for 3 months (Warwick et al 2003, Gasson 2005). SHAP assessments were conducted on both limbs, prior to implantation, during its use and after removal. Other measures of hand and arm condition were also undertaken. The use of SHAP aimed to monitor if this experimental procedure had any detrimental effect on the participant. The participant showed no signs that neurological or functional deficits occurred as a result of the procedure. The results indicate a score within the normal range throughout the experiment (Table 5), although a slight reduction in Power grip function was seen.

Fig. 2. Comparison of the performance of the different designs of prostheses. The results are scaled (normalised) relative to the overall score showing the relative performance of different grip types. This indicates that the Tip-type grip does most poorly despite the prosthesis being set in this grip.

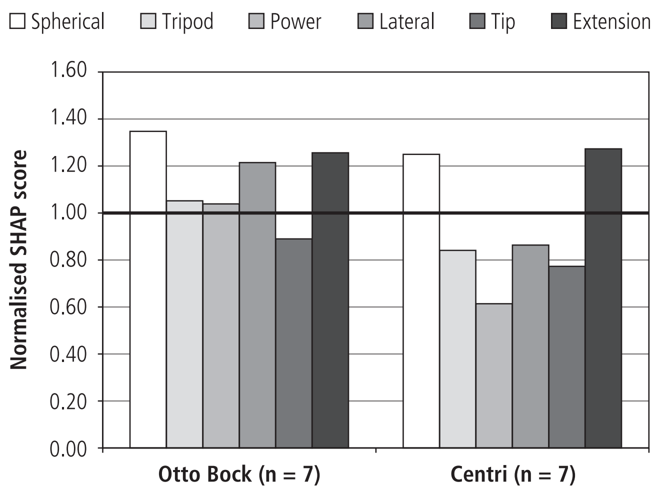


Table 5. Results of the use of the Southampton Hand Assessment Procedure with participant M1, before, during and after implantation compared with his contralateral (dominant) hand; there is little measurable effect on the person's dexterity, which confirmed other observations of the participant

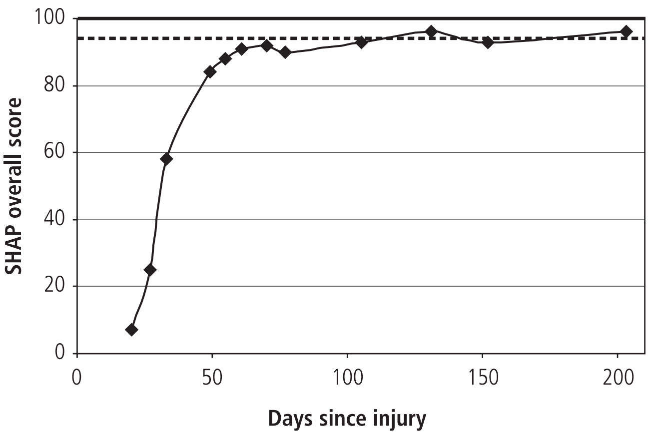
Category	Dominant hand	Before implantation	During use	After explantation
Overall	**97**	**98**	**97**	**98**
Spherical	95	98	93	96
Tripod	98	96	97	99
Power	99	98	99	96
Lateral	96	96	97	98
Tip	96	97	95	98
Extension	95	96	97	98

Participant M2

A 24-year-old female had a fracture of her fifth metacarpal head during sport. She was splinted post-trauma. After 20 days (when she could tolerate working without the splint), she was assessed at intervals until 203 days post-injury.

The participant improved her overall functional rating from 6 to 96 points (Fig. 3). The improvement was independently monitored by the clinical team treating the patient, who judged recovery to be in line with normal progress.

Fig. 3. Recovery of participant M2 (fracture of the fifth metacarpal head) shown by the Southampton Hand Assessment Procedure overall score. The 100 line marks optimum score; normal range is above 95 (dotted line).



The scores were also normalised (Figs 4 and 5). This highlights the relative performance of the grips at different stages in the recovery. The data are shown for two periods: up to day 70, and from day 50. Early on, the ability to exert Power through grip was reduced and Tripod was least affected by the injury. As recovery continues, it was Extension that had the poorest performance due to the involvement of the fifth digit, which sustained the injury. As the recovery progressed, there was a shift from the lack of grip strength being the limiting factor in some grips to RoM limiting performance.

Fig. 4. Recovery of participant M2, showing the individual grip scores divided by the overall score. This scaling allows observation of the capability of each grip type relative to the overall performance (note difference in scale to Fig. 5). The normalisation emphasises the differences between performance. Participant M2 was barely able to perform a Power grip on the first two sessions (6 and 0), so that the grip score is low on both. Because the overall score on the second set of readings is much greater (25), as opposed to 7 on the first run, the first normalised score is close to one and for the second session it is very small.

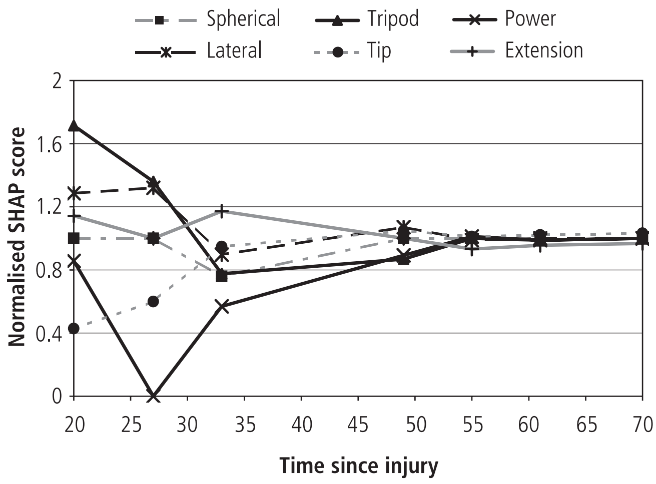
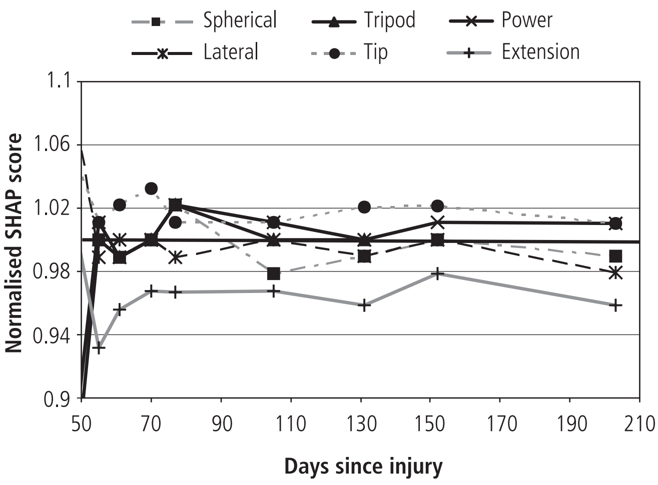


Fig. 5. Latter stages of the recovery of participant M2, showing the individual grip scores divided by the overall score. This shows that the Extension grip was affected for longer than any other grip (note difference in scale to Fig. 4).



Discussion

Single assessments

These cases demonstrate a range of conditions for which SHAP can be employed. In the Swanson's amputation system (Swanson et al 1987), the higher the level of amputation the higher the impairment, so participant A2 is 32% impaired whereas participant A3 has a 64% impairment. The SHAP score reflects this.

Distal radial fractures

The effects of the injury can be seen for extra-articular and intra-articular fractures. The kinematics of the motion were also measured. The SHAP form-board controls the motions so that it acts as a template for the activities, which allows the different participants' actions to be compared directly. Each individual task is made cyclic through the use of the timer; the task starts with the hand under test, on the timer, and finishes at the same location. The result is that SHAP's cyclic nature creates a system analogous to gait measurements, with each trajectory being closely controlled and so easily compared (Murgia et al 2004, 2005a, 2005b). Regions of normal and abnormal motions are clearly defined. So it can be seen that while SHAP alone cannot reveal compensatory movements, by adding motion analysis, these actions become apparent. SHAP helps to create a systematic means to measure upper limb motion, not previously achieved.

Prosthesis users

The comparison of different prostheses confirms that current mechanical designs are very limited in their functional ranges and highlights the designs' shortcomings. Larger hands show greater functionality, because the hand can open wider and admit the larger objects.

Progress monitoring

These examples show the test's ability to make repeated observations of a participant and monitor change or improvement.

For participant M2, the overall score shows the time at which full function is returned (Fig. 3). However, through normalisation it becomes apparent which grips take longest to recover. This shows that the procedure is sensitive enough to reveal differences, even while the participant may appear to have regained full function.

Conclusion

The Southampton Hand Assessment Procedure was designed to make the functional assessment of hands as simple and as straightforward as possible. The achievement of this aim has been demonstrated here using a range of example cases.

The test enabled direct comparisons to be made between the participants, and also for the same participant over time, allowing monitoring of the functionality of a person's hand at the start, during and at the end of treatment. As the SHAP scores can be divided into individual scores for the six basic grips, SHAP can be used to detect a difference in the recovery of one of the grips, even when the overall score has returned to the normal range and the assessment would seem to conclude that the participant had already fully recovered. Tests on different prosthesis designs allowed identification of which grip types are better served for a given design and indicate where improvements can be made.

It is important to use SHAP appropriately. It is designed to measure the function of the hand, so it is not possible to use SHAP alone to measure impairments of other parts of the upper limb. However, it can be used in conjunction with other tools (such as motion analysis) to gain insight into the functional abilities of the entire limb.

The range of example cases presented here demonstrates the potential breadth of applications of SHAP within the field of upper limb rehabilitation.

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Key messages

- SHAP is a simple measure of hand functionality.
- SHAP can be used to monitor progress and compare performance.
- Used in conjunction with other tools, it can observe the function of the entire limb.

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Focus on research

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Sarah Stevens

What is the evidence to suggest that adaptive seating can improve postural control and upper extremity function in children with cerebral palsy?

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Occupational therapists regularly recommend the use of adaptive seating for children with cerebral palsy (CP) who have difficulties acquiring and retaining postural control (Wandel 2000). Children with CP benefit from postural intervention in terms of enhanced cognitive function, dexterity and communication skills: all precursors to improved learning and participation (Farley et al 2003). However, the literature shows much debate in terms of the positioning of the child's seat in order to achieve maximum postural control and consequent improved upper extremity performance.

The purpose of this study is to review and critically appraise the current literature regarding the effects of various seating positions on the postural management and upper extremity function in children with CP. A literature search was conducted using electronic databases, hand searching of relevant journals and ancestral searching from reference lists. Nine appropriate studies were identified focusing on the outcome measures of postural control and upper extremity function of children with CP in relation to different seating types, incorporating various seating inclinations and seat bases.

All of the studies support the use of adapted seating, yet conflicting evidence is apparent on what seating type actually constitutes the best overall outcomes. Taken as a whole, strong evidence insinuates that children with CP should be assessed for seating according to individual need, all the while ensuring that a functional sitting position is achieved, reducing spasticity and enhancing postural control, in order to promote the maximum degree of independence when using the upper extremities for functional activities.

Nevertheless, throughout this critical review it has become apparent that the literature is very outdated, causing considerable implications for occupational therapists who are just accepting standard practice without questioning it (Stavness 2006). Therefore, it is essential that further research in this area be conducted, with more rigorous study designs implemented so as to create more innovative evidence for the future.