ORIGINAL PAPERS

A REVIEW OF THE SHARPENED ROMBERG TEST IN DIVING MEDICINE

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Abstract

The use of the sharpened Romberg test (SRT) was evaluated in injured divers. Over a 12 month period, thirty five divers presenting with decompression illness (DCI) to the Naval Base in Auckland were assessed before hyperbaric treatment and at discharge. Their scores were compared with those of an age and sex matched control group (n=60). Abnormal SRTs were seen in 49% of divers (n=17) before treatment. These results were significantly improved at discharge ($p<0.001$). The results in injured divers were significantly lower than controls at presentation ($p<0.001$), but not at discharge. The SRT is consequently considered to be a valuable examination in divers who suffer DCI. It is proposed that the SRT be conducted in a standardised manner and be scored as the best attempt of four.

Key Words

Decompression illness, investigations, treatment.

Introduction

Neurology only developed as an independent discipline in the second half of the 19th century, due to the delayed discovery of the underlying neuroanatomy and physiology.[1] Moritz Romberg (1795-1873) was involved in early clinical research of the physiology and pathology of the nervous system.[1,2] He is credited with writing the first textbook of neurology and described the sign which bears his name in 1851.[1-3] The earliest description of a modified (sharpened) Romberg test was in 1944.[4]

The Romberg test has become part of the routine assessment of gait and equilibrium.[5] When the sign is positive, it is generally said to be diagnostic of proprioceptive deficiency (disorders of the posterior column of the spinal cord).[6-9] It is also regarded as a useful indicator of vestibular impairment.[10-12] A positive Romberg sign is also found in unilateral or bilateral motor weakness, diseases of the peripheral nerves, cerebellar disease and vertebrobasilar disease.[5,8,9,12,13]

The sharpened Romberg test

In this investigation the subjects wore flat shoes or bare feet and were assessed on a flat surface. They stood heel to toe (tandem position), with their arms crossed so that the open palm fell across the opposite shoulder. The patients closed their eyes once they were stable. They tried to maintain this position for 60 seconds, or for four trials, if 60 seconds was unattainable. A completed test of 60 seconds was scored as 60 for each subsequent trial e.g. if the subject stood for 60 seconds on the first attempt, they would score 60 x 4 = 240. If they completed 15 seconds initially and then 60 seconds on the second attempt, they scored 15 + (60 x 3) = 195. Patients continued with the trial until they had stood for 60 seconds or until they had completed four trials.[11,15]

The SRT, also known as the tandem, augmented or modified Romberg test, is more sensitive and can be quantified.[10-14] This test is generally described as a reliable indicator of a loss of vestibular function,[10,11] cerebral ataxia, sensory ataxia, and sensory neuropathy.[13] The test is more sensitive than the standard neurological examination for assessing changes over time and hence is useful in assessing clinical deterioration.[13]

Two US Naval medical officers assessed the value of Barbey's SRT in the evaluation of ataxia in aircrew in the mid to late 1960s.[4,10,11,15] This has been followed by considerable ongoing evaluation of the test in aircrew and in patients with disequilibrium.[3,10,11,13-17] By the early 1970s, the test was also considered to be useful in diving.[18] It is now used by several Navies (USN, RAN, RNZN) in their diving programs and is regarded as being useful in diving medicine as a baseline and in the assessment of patients with dysbaric illness and injuries.[19-20]

Although the SRT is used in the examination of patients with DCI, the application and interpretation of this test is usually neither standardised nor understood. The SRT requires more skill than the classical Romberg test.[3] One group of researchers suggested that although the SRT was useful in the assessment of gross balance abnormalities, the Stand on One Leg with the Eyes Closed test (SOLEC) was better for fine distinction in balance performance.[3] This claim was not supported by data. For this test the subjects stand with their arms folded against the chest. They stand for 30 seconds, or for 5 trials. Times are added and scored out of 150. A completed test of 30 seconds is scored as 30 seconds for each subsequent trial (as for the SRT). The trial needs to be repeated on each leg (SOLEC-L and SOLEC-R).[11,15.]

It has also been suggested that while the SRT is one of the many available quantifiable, clinical, vestibular function tests, that it has no greater value than the other tests in this group.[18] Again, no trial has been conducted to test this hypothesis.

The SRT has been shown to worsen with increasing age.[3,4,10,11,17] This decline in scores begins after age 40 in males and 30 in females.[11,13] Explanations for this phenomenon include: ageing of the peripheral nervous system causing an impairment of proprioception; a decrease in muscle mass; a decrease in muscle strength; a decrease in exercise levels and fitness; and an increase in the use of prescription medications by the elderly that effect balance and co-ordination when standing.[3,13,17] The reason for the differences between males and females is unknown and may not be real, as the numbers of females tested have been small.

A common criticism of the SRT is that there is a practice effect. This is controversial; one study supported this claim,[16] another disputed the argument[13] and a third study found that while this was the case in controls, it was not true for those with disease (labyrinthine disorders).[11]

Similarly, claims of dominance effects are not supported by a study that showed that there was no difference in performance when using the left foot in front of the right or vice versa and that there was no difference in performing the test with flat shoes on or in bare feet.[3]

The purpose of this study is to examine the SRT by analysing data from a control group of subjects performing the test and from divers with DCI.

Method

Two surveys were conducted. The first was a prospective review of the SRT in 60 control subjects. The second was a retrospective review of the last 35 cases of DCI presenting to the Royal New Zealand Naval Hospital (RNZNH) during 1994 and 1995. Individuals in each group were surveyed to ensure that they did not have any medical problems which could influence the test. Exclusion criteria included: disorders of the posterior column of the spinal cord, vestibular impairment, history of inner ear trauma or damage, unilateral or bilateral motor weakness, diseases of the peripheral nerves, cerebellar disease, vertebrobasilar disease, acute pain of the lower back or lower limbs, back surgery, and either a significant back injury resulting in persisting and current symptoms or a history of balance difficulties. In this study, patients were advised not to practise the SRT.

Subjects

The control group consisted of volunteers from HMNZS PHILOMEL (Navy and civilian) and Naval personnel presenting for routine medical examinations at the Royal New Zealand Naval Hospital (RNZNH). This population was chosen as reasonable age and sex matching was likely given the similar age and gender distribution in the Naval population and the divers treated at RNZNH for DCI.[21] Two patients were excluded from this group due to a past medical history of significant back injury.

The study group were divers treated at RNZNH for DCI. One diver was excluded after it was discovered that he a five year history of vertigo after an episode of inner ear barotrauma. Three other patients were not able to be included because the duty medical officer either failed to measure or did not record the SRT before hyperbaric treatment (these patients had normal scores on discharge).

The data for the divers and controls were compared using unpaired t-tests, assuming equal variance. The SRT scores for divers before hyperbaric treatment and at discharge were compared by paired t-test. A significance level of p=0.05 was chosen.

Results

The data for the control group are displayed in Table 1. The data for the divers with DCI are displayed in three tables. Table 2 shows the data at presentation and Table 3 the data at discharge. Table 4 shows the data for only those divers whose SRT was less than 30 seconds at presentation. The SRT mean value is the group mean of the cumulative trial scores. The best mean value cited is the group mean calculated from a subject's best individual trial score, i.e. the best score taken from the four trials.

TABLE 1.

SHARPENED ROMBERG TEST SCORE IN CONTROL SUBJECTS.

	Number	SRT mean	SD	Best [mean]	Best [SD]
Total	60	210.8	47.30	59.1	5.55
20-40 years	54	215.65	39.26	59.78	1.38
Over 40 years	6	167.17	86.74	53	17.15
Male	42	218.93	35.46	60	0
Female	18	191.83	64.72	57	10.02

TABLE 2.

SHARPENED ROMBERG TEST SCORE IN DIVING PATIENTS, AT PRESENTATION.

	Number	SRT mean	SD	Best [mean]	Best [SD]
Total	35	114.17	104.48	32.37	27.00
20-40 years	26	146.35	100.94	40.88	25.24
Over 40 years	9	21.22	38.29	7.78	13.88
Male	27	111.63	106.17	31.52	27.35
Female	8	122.75	105.10	35.25	27.42

TABLE 3

SHARPENED ROMBERG TEST SCORE IN DIVING PATIENTS AT DISCHARGE.

	Number	SRT mean	SD	Best [mean]	Best [SD]
Total	35	201	63.98	54.91	13.53
20-40 years	16	216.96	41.75	58.27	6.12
Over 40 years	9	154.89	93.44	45.22	22.78
Male	27	196.67	69.74	53.70	15.19
Female	8	215.62	38.76	59	2.83

TABLE 4

SHARPENED ROMBERG TEST SCORE IN DIVING PATIENTS WITH AN ABNORMAL RESULT (LESS THAN 30 SECONDS) BEFORE HYPERBARIC TREATMENT [HBO], AND AT DISCHARGE.

	Number	Pre-HBO Best [mean]	Pre-HBO Best [SD]	Discharge Best [mean]	Discharge Best [SD]
Total	17	5.94	7.93	50.88	18.01
20-40 years	9	8.11	9.31	57.56	7.33
Over 40 years	8				

The controls were aged between 18 and 49 years (mean = 28.93 ± 0.98 SD). There were 42 males aged between 19 and 47 (mean = 28.98 ± 1.09 SD) and 18 females aged between 19 and 49 (mean = 28.93 ± 2.09 SD).

The patients with DCI were aged between 17 and 53 (mean = 32.66 ± 1.68S SD). There were 27 males aged between 17 and 53 (mean = 34.89 ± 1.80 SD) and 8 females aged from 17 to 49 years (mean = 25.12 ± 3.57 SD). The mean age of the divers was not statistically different from that of the controls.

The time from the accident to the diver's presentation at the Naval Hospital (and hence assessment) varied from almost immediately after completing the dive to 5 days after diving (mean = 1.59 days ± 1.47 SD).

The group mean of cumulative trial SRT scores for controls was 210.8 (out of 240) ± 47.30 SD. The cumulative score mean for divers on presentation was 114.17 ± 104.48 SD. At discharge, this mean had improved to 201 ± 63.98 SD. The control group mean for their SRT best score was 59.1 (out of 60) ± 5.55 SD. The divers best score mean was 32.37 ± 27.00 SD, at presentation. At discharge, this mean had improved to 54.9 ± 13.53 SD.

A SRT best score at presentation of less than 30 seconds was recorded in 17 (48.57%) divers in this trial. The mean best score in the remaining 18 divers was not statistically different from that of the control group (mean = 57.33 ± 1.51 SD). That is, the best SRT score in divers was either indistinguishable from normal (controls) or less than half the maximum score (mean = 5.94 ± 8.1 SD).

Divers with DCI were almost equally distributed between the two groups (18 and 17 respectively). The mean SRT best score at presentation for the divers was statistically different from the controls ($p < 0.001$). The mean best SRT score at discharge was still significantly less than that of the controls ($p < 0.05$). However, the divers mean best presentation SRT score was significantly different from their mean best discharge score ($p < 0.001$). Amongst the 17 divers with DCI who had a best SRT score less than 30 seconds, 2 had little or no improvement, a further 3 had improvement to greater than 30 seconds, but considerably less than 60 seconds, while the remaining 12 improved to record essentially perfect best SRT scores.

The difference between divers with DCI at discharge and controls was age related. The mean best SRT score data in divers at discharge was not significantly different from that of the controls, if divers and controls aged 40 years or less were considered only.

Discussion

The results of this study indicate that there are changes induced in the balance system in DCI, which are reflected in the best score with SRT. These changes could involve any or all of the components which contribute towards equilibrium.[5-13,18] The SRT is a quantifiable method of measuring these changes and is consequently useful in the assessment of DCI. It is even possible that the SRT could be used as a "marker" for DCI. The SRT was abnormal in 49% of patients with DCI in this trial. Thus for a patient where the disease process was in question, an abnormal SRT could be used to support a diagnosis of DCI. Grouped scores of the cumulative SRT were less discriminatory and had less value for comparison than the best trial SRT. With the cumulative score, some patients would repeatedly score approximately the same time for each trial. However, the majority have a wide range of scores. The cumulative score had a wider standard deviation. The best trial SRT score provided an isolated view of a patient's ability, and was directly comparable with the results of other divers. It was a more discriminatory measurement.

The data presented here suggest that a score of 48 or greater on a single SRT trial is normal (i.e. mean of controls ± 2 SD). In contrast, previous reports variously state that: a score of better than 30 seconds on any one attempt is normal;[3,12] a single score of 15 seconds is normal;[18] and a score of less than 15 is abnormal, when assessing patients with vestibular dysfunction and major abnormalities of equilibrium.[11,14]

The mean best SRT score for the divers with DCI was just higher than 30 seconds. However, this population was heterogeneous and consisted of almost equal sub-groups of divers with either an essentially perfect best SRT score (mean = 57.33 ± 1.51 SD) or a group with a mean best SRT value of only 5.94 seconds (SD = 7.93).

This suggests that an abnormal result should be regarded as any best SRT score of less than 22 seconds (5.94 + 2 SD). Of the 17 divers with DCI who had a best SRT score of less than 30 seconds, only 5 recorded 15 seconds or better. The other 12 scored less than 10 seconds and 11 were less than 5 seconds. This heterogeneity has been noticed previously amongst divers with DCI.[18]

From these data, and assuming that 99% of patients with an "abnormal" SRT score would be found from the mean of the scores plus three standard deviations, it is proposed that any score of less than 30 seconds be considered abnormal.

The SRT should be performed in the method described in Appendix B to achieve consistency. It is recommended that the test be scored as the best time out of 60 seconds (i.e. the score from the best trial of four). The best SRT score provides a readily comparable value. It also permits assessment of whether it is a normal result.

Divers aged between 20 and 40 years who demonstrated an abnormal initial best SRT score, had a discharge score which was not statistically different from that achieved by the control group. This suggests that the divers' posture had returned to normal and that age may be a risk factor for long term invalidity in DCI. Given that the entire group of divers with DCI showed a mean improvement from presentation to discharge, it can also be argued that the SRT is often a sensitive measure of clinical progress in divers with DCI.

It would be valuable to compare patients with DCI with their dive buddies. The buddies would provide an excellent control group, usually being age, sex and fitness level matched, and having dived the same or similar dive profiles without developing illness. This could provide information on whether the abnormal SRT in divers was due to DCI or was a reflection of decompression stress.

In summary, the SRT is a useful and sensitive test of equilibrium and is especially useful in the assessment of divers. It may even provide a diagnostic "marker" for DCI. It is recommended that the test be performed in the standard format given earlier, recording the best trial time of four attempts aiming at a time of 60 seconds.

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DOPPLER BUBBLE DETECTION AFTER HYPERBARIC EXPOSURE

Margaret Walker

Abstract

A review of the literature on the use of transcutaneous Doppler to detect circulating venous bubbles occurring after hyperbaric exposure, with emphasis on the detection of bubbles occurring after relatively small decrements in pressure, is presented. The correlation between circulating bubbles and the occurrence of decompression illness is examined.

Key Words

Bubbles, decompression illness, investigations.

Introduction

Decompression illness (DCI) may occur in many different organisms following a reduction in ambient pressure exposure. The illness is thought to develop as a result of the formation of an endogenous gas phase taking the form of small inert gas bubbles which are widespread throughout the blood and body tissues.[1] The symptoms produced by these bubbles will depend on their size, number and location. Gas bubbles in the microcirculation or moving in the venous circulation may apparently produce no clinical symptoms, whereas a bubble of similar size in the tissues may produce symptoms due to tissue distortion or damage, especially in the nervous system.[2,3] Circulating venous bubbles indicate that gas phase separation has occurred, and that bubbles may exist elsewhere in the body tissues.[4] The growth of gas bubbles in the tissues by gaseous diffusion may produce symptoms some time after the initial decompression has occurred.[2,3] Gas bubbles normally appear and grow after decompression. Rapid decompression or a large gas load, or both, leads to the earlier appearance of bubbles.

The magnitude of the decrement in pressure exposure which can be safely tolerated by humans is of fundamental importance in the field of hyperbaric medicine, where patients and attendants alike are exposed to elevated ambient pressure during routine treatment profiles. The treatment regimes currently in use throughout the world are considered to be safe in that the incidence of DCI in the attendants is negligible, though not zero. However, it is not known if small asymptomatic bubbles may be occurring during these exposures which may cause morbidity in the long term, especially where the attendants have repeated hyperbaric exposure (in some centres more than once daily).