

Papers and Originals

Accidental Hypothermia in Walkers, Climbers, and Campers : Report to the Medical Commission on Accident Prevention

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Death from exposure is the coroner's usual verdict when a hill walker or climber is found dead by a search party and there are no injuries to account for death. Cases occur every year in the hilly regions of Britain but are seldom reported except in the popular press. It seems safe to assume that hypothermia is the cause of death in these cases, though there is no proof of this. Accidental hypothermia also occurs among potholers (Lloyd, 1964), yachtsmen, and dinghy sailors as a result of immersion in cold water, but this paper deals with the special problems of the first group. The causes and symptomatology of this type of hypothermia are described and methods of prevention suggested.

Sources of Information

The case histories have been grouped according to district. The incidents from North Wales were collected by Dr. I. Jones while acting as Resident Casualty Officer at the Caernarvon and Anglesey General Hospital. Eight of the persons concerned were successfully contacted and completed a questionnaire and/or sent personal accounts of their experiences. I am indebted to Group Captain P. A. Wilkinson for a detailed account of the R.A.F. incident (Case 10), to the Outward Bound Trust, and the Duke of Edinburgh's Award Scheme for access to records of inquiries into their cases. The Four Inns Walk case has been reported previously (Pugh, 1964). Three of the cases from Scotland and three from Cumberland were contributed by Dr. D. G. Duff. Two recent cases occurring in April/May 1965 have been included.

Case Histories *

Wales

Incident 1

Four friends, aged 15 to 24, set off at 11.00 hours on 30 January 1960 to walk to the summit of Snowdon by the Pyg Track. Their previous experience was small. The party reached the summit at 14.30 hours wet and cold. It returned by the miners' track. On the way down A. B., aged 18, began to tire and slowed the others. The party reached the causeway at 17.10 hours and found it flooded. By this time everyone was tired and A. B. was exhausted. It was getting dark and they had no torches. They began to traverse the slopes around the lower part of Llydaw; A. B. had to be assisted. They missed their way and one of the boys fell some 15 feet (460 cm.) down a crag but was not injured. Despite this warning, A. B., who was dazed, also fell down the same crag and rolled a further 20 feet (600 cm.), sustaining facial injuries. After this he was only semi-conscious. All four of them then huddled together in the shelter of some boulders. A. B. died one or two hours later. The others survived. Necropsy showed no cerebral injury but fairly severe facial injuries with a fracture of the mandible. The cause of death was given as exposure and shock.

* In each incident the casualties are designated by the letters, A. B., C. D., E. F., and so on. Thus casualties in different incidents designated by the same letters are not the same people.

Incident 2

On 2 April 1960 a party of 18 schoolboys, aged 12 to 15, in charge of a master, set off from a youth hostel to walk the whole length of the Carneddau ridge from Capel to Ogwen. The weather was so bad that Ogwen Cottage Mountain School had not sent any parties out in the hills that day. One boy, A. B., became exhausted on Pen-yr-Oleu-Wen after five hours of walking. He was rescued within one hour and brought down on a stretcher by two instructors from the Mountain School. They found him unconscious but alive. Meanwhile another member of the party arrived back and reported two more casualties on the Llywelyn-Dafydd ridge. These boys were found by a rescue party and brought down on the same stretcher "like sardines, one facing each way." One was in a state of collapse but still conscious and the other had severe cramp in the leg.

While the rescue was in progress the master in charge was heard to remark that he had very bad luck in these matters, as he had already had one accident to members of a party in his care in the Lake District and one in Scotland.

A. B. was not admitted to hospital until 03.00 hours. The reasons for the long delay are not clear, but attempts may have been made to revive him at Ogwen. On examination he was unconscious, extremely cold, pale, and nearly pulseless. Breathing was stertorous. Pupils were widely dilated, and there was generalized muscular rigidity with exaggerated tendon reflexes. He became violent when attempts were made to rouse him. He was given 2 ml. of nikethamide, and put to bed with hot blankets and hot-water bottles. His condition slowly improved during the night and he was fully conscious next morning. He was discharged on 4 April, the following day.

This boy was traced and gave the following details. Age at time of accident 15; height 5 feet 7 inches (168 cm.), weight 112 to 126 lb. (50.8 kg. to 57.2 kg.). Conditions: rain, high wind, temperature near freezing point. Clothing: combat jacket, pullover, shirt, flannel vest, corduroy trousers, drawers, two pairs of socks, boots. Spare clothing: cap, cape, and gloves—all lost in the wind about two hours after the start. He was wet through all over. Unusually fatigued for distance traversed because of high wind and too fast a pace. Symptoms came on gradually and consisted in muscular weakness, fatigue, slowing, stumbling, cold. Mental state was one of anxiety.

Incident 3

A party of Royal Marine commandos were engaged in a hill-walking and navigation exercise, which was part of an instructors' course. At 08.55 hours on 30 November 1960 six students set off in pairs from Llanberis on a 15-mile course over the mountains. There were check-points at intervals. At the start there was some rain but little wind. All went well at first. The officer in charge and a sergeant, having checked in the parties at the first check-point, proceeded to the finishing point and started to walk the course in reverse. They found the first pair going well, but one of the second pair had cramp, and they helped them down to the finish. At 17.30 hours a member of the last pair, Corporal A. B., reached the waterworks at the bottom of Cwm Llafar in a state

of exhaustion and gave the alarm. He reported that his companion, C. D., aged 20, had become exhausted on the ridge between Dafydd and Llywelyn. He had helped and later carried him to the summit of Carnedd Llewelyn, where there should have been a check-point, but finding no one there he had tried to carry him down but failed. The weather was now very bad and the strong winds impeded progress. He had left him in a hollow protected by a small stone wall within 20 yards (18 m.) of the summit, and, leaving whistle, torch, and spare clothing, had made his way down to get help. A search party of Marines with a local guide set out immediately, but the going was very difficult because of darkness and a hurricane-force wind. Two members of this party had to return and were taken to hospital suffering from exposure. The remainder reached the summit and searched for two hours without success. Other parties found the body of C. D. next morning 100 yards (90 m.) below the summit and lying on ground partly covered by snow. There was evidence that he had crawled some distance from the spot where he had been left. Dr. Jones estimated that he had died shortly after Corporal A. B. had left him. He was wearing a vest, shirt, trousers, Army sweater, anorak, and windproof over-trousers.

Corporal A. B. was given a hot drink and dry clothing and taken to hospital. On admission his general condition was quite good. Mouth temperature was 98.2° F. (36.8° C.), B.P. 150/100. Pulse rate 96/min., regular. Heart sounds normal. He was given a hot bath and was discharged after two hours' bed rest. Next day he took part in the search for his companion.

Three other commandos who had taken part in the night search were admitted to hospital suffering from exhaustion. One of them had been blown off his feet and carried several yards into a stream. The findings recorded were as follows: Corporal E. F., aged 23: pulse rate 70/min., B.P. 120/70. Sergeant H. I., aged 25: mouth temperature 97.2° F. (36.2° C.), pulse rate 90/min., B.P. 170/110, crepitations over right lower lobe. Admitted overnight; chest clear next morning; x-ray normal. Lieutenant J. K., aged 25: no abnormality on clinical examination. Corporal E. F. and Lieutenant J. K. took part in the search next day.

Corporal E. F. was traced and submitted the following information. Age 24; height 5 feet 8 inches (170 cm.), weight 144 lb. (65.3 kg.). The weather was very severe, with rain, snow, and high wind: the temperature was near freezing point. Clothing was as follows: combat jacket, denim trousers, heavy pullover, angola shirt, vest, and drawers, two pairs of socks, boots, and puttees. He was wet through all over. He and another man had set out at 12.30 hours to occupy the check-point on Carnedd Llewelyn but had never reached it. About 18.00 hours the following symptoms came on: muscular weakness, slowing of pace, stumbling. Mental state "very light-headed, felt as if I were a little drunk." He and his companions did not go on to the point of collapse but took shelter under some rocks and later went down. They had already been to the top of Carnedd Llewelyn twice on that day before setting out to look for the missing Marine.

Sergeant H. I. was also traced. Age 23, height 5 feet 8 inches (170 cm.), weight 154 lb. (69.9 g.). He set out with a rescue party at 18.30 hours. He was wearing clothing similar to that worn by Corporal E. F. and was wet through when he got back to base. He felt cold and tired and was shivering violently. He thinks he got tired because he got blown into a stream and hurt his leg, which caused him to go slow. Sergeant H. I. pointed out that of six men taking part in the exercise the only two who had trouble—C. D., who died, and his companion—had both returned from Aden recently. He also described meeting Corporal A. B., one of the pairs coming off the mountain in the afternoon. He was very fatigued and was being led by his partner because "he was just not with it." He was therefore sent back to the hut, where he was given a hot bath and hot food, of which he later remembered nothing.

Incident 4

A. B., an Indian woman, aged 42, was wandering around the country on her own carrying her belongings in bags of various descriptions. She was trying to see the world and had decided that one of the things she had to do was to climb Snowdon. In November 1961 she walked up the path from Llanberis. The ground was partly covered by snow, and soon the wind became strong. She was blown over and fell heavily several times, but

finally reached the hotel, only to find it locked and empty. Darkness fell and it was blowing too hard for her to descend. She therefore spent the night on the summit. She was unconscious for long periods but remembered waking and finding no sensation below the hips. By good fortune a railway worker went up to the summit in the morning and found her unconscious with her clothes frozen stiff—dead as far as he could see. He sent for a train which brought her down, by which time she had recovered consciousness. On examination in hospital she was fully conscious and talkative. She was wearing ordinary clothing with extra cardigans. Her body felt very cold. She was given a hot bath and her temperature, recorded for the first time four hours later, was 100° F. (37.8° C.). She remained in hospital three days and was finally discharged to a mental institution.

Incident 5

A party of eight boys in charge of a master camped on the southern slopes of Moel Siabod in December 1961. They were accompanied by the warden of the hostel at which they were staying; he was the only one with any real mountain experience. During the night there was a very high wind and rain, and in the small hours when their tents had been blown down and they were all wet and cold they decided to return to the school. They walked down, the warden leading and the master moving along the column. Somewhere along the route it was found that two boys were missing. A search was unsuccessful, and the remainder moved on down to the school, where they arrived in a state of exhaustion.

The missing boys wandered around the mountain until, at first light, one of them (A. B.) collapsed. The other found his way down and led a search party back to his companion. A. B. was carried down and placed in an ambulance. When Dr. Jones arrived the ambulance driver was not sure whether the boy was dead or not. He was deeply unconscious; there was no palpable pulse; breathing was very shallow; and the body was cold. I.V. infusion was begun, and a bottle of plasma was given rapidly with two vials of nikethamide. He was wrapped in blankets with hot-water bottles. Fifteen minutes later he opened his eyes and spoke, but thereafter he remained stuporous but rousable. On admission to hospital his temperature was not recordable on a clinical thermometer. He was put to bed with hot-water bottles, but his condition deteriorated and he became practically pulseless. The foot of the bed was elevated and a heat cradle placed over him. He soon recovered consciousness under the cradle, but it was three hours before his temperature was recordable. By 22.00 hours his temperature was normal. He made an uneventful recovery and was discharged on the fourth day.

Incident 6

A party of 24 members of Liverpool University Mountaineering Club arrived in North Wales on 25 January 1962. Conditions were wintry, and there was much snow on the hills. Next day two members of the party, A. B., aged 31, and a companion C. D., set off to do the Snowdon Horse Shoe via Pen y Pass. Neither had any knowledge of North Wales or experience in snow and ice work, though they had reasonable rambling experience. They were warmly clad and carried an ice axe each and a rope. They reached the summit of Crib Goch at 14.00 hours and sat down for sandwiches and coffee. The weather was still bright and clear. While they were on their way to Crib y Ddysgl the weather deteriorated and they decided to retreat by going down the steep slopes towards the miners' track and the lakes. On the way down they both slid some 30 yards (27 m.) down a snowy slope but sustained no injury. A blizzard was soon blowing and they sheltered for a short while behind some boulders. They then set off again and A. B. soon fell into a snowdrift. He came to no serious harm but began to complain of pain in one leg. After this they roped up. Soon A. B. became exhausted and collapsed. Thereafter his companion half dragged and half carried him down. Finally they reached the shores of Llydaw in the dark at about 19.00 hours. He cleared the snow from the lee side of a boulder and placed A. B. in this shelter, later building a snow wall around him. He tried moving his legs and arms, and later lay on top of him to keep him warm. After some hours A. B. became semi-conscious and mumbled a lot. At 03.30 hours on 27 January his limbs were flaccid and he showed no sign of life. At dawn his companion set off for Pen y

Pass and was found at 11.30 hours by a search party, having walked only half a mile from the spot where he had spent the night. He was not admitted to hospital.

Incident 7

A. B., aged 35, and his brother C. D., aged 16, set out on 24 August 1962 in heavy rain and mist to walk across Carneddau ridge. When they reached the ridge visibility was poor and there was a strong wind. They had a compass but appeared to be walking in circles. Eventually they began walking one on either side of the ridge. Communication was impossible because of the wind, and after some time they lost contact. When darkness fell, C. D. lay down behind some rocks and slept. He woke later, moved to a better shelter, and slept again. At daylight he found he could not move his legs. The weather was clear but by the time sensation returned to his legs it had deteriorated again and he sat there until early afternoon. Eventually the weather cleared and he found his brother dead within 50 yards (45 m.). He made his way down to Bethesda and gave the alarm. His brother, who was an experienced hill walker, was found sitting below the crest of the ridge with his rucksack on his back with a sleeping bag in it. He was wearing a cellular vest and pants, a thin khaki shirt, denim trousers, and an anorak.

Incident 8

A party of six—five youths and a schoolmaster—set out at 09.30 hours one day in October 1962 to climb on Glyder Fach. The schoolmaster, A. B., was 39 years of age and relatively unfit; the average age of the others was 19. It was raining and there was a moderate to severe wind; the temperature was average for the season, say, 15° C. A. B. was wearing an anorak, sweater, shirt, singlet, string drawers, cord breeches, two pairs of socks, climbing boots. He was wet through all over, and the pace was too fast for him. About 15.30 hours he began to develop symptoms in the following order: muscular weakness, slowing of pace, fatigue, stumbling, cold. His mental state was normal at first. He became anxious when he began to lag behind but was later apathetic. He went on almost to the point of collapse before taking shelter behind some rocks, where he fell asleep about 20.00 hours. He appears to have been rescued and admitted to hospital that night. On examination: pulse rate 80/min., B.P. 130/90. No abnormal findings. Discharged next day. Comment: ambient temperature probably too high for hypothermia, and clothing insulation higher than average. Good description of early symptoms.

Incident 9

A party of three inexperienced young men set out to climb Idwal on 16 November 1962 at 11.15 hours. The temperature was below freezing point and the wind moderate. There was drizzle at first turning to heavy snow later. The party carried on until it got dark. They had come to a precipice and were later rescued at this point. One of the party, A. B., was admitted to hospital. Age 21, height 6 feet 1½ inches (186 cm.), weight 191 lb. (86.6 kg.). His clothing consisted of sports coat, thin jeans, drawers, shirt, sweater, duffel coat, suede shoes. He was wet through all over. Symptoms were fatigue, numbness, and violent shivering. He felt dissociated as if watching someone else. The hospital notes recorded that he was cyanosed and confused; his hands and feet were swollen, and he had lost one shoe in the snow. Admitted for observation and discharged next day.

Incident 10

A. B., an R.A.F. corporal, aged 36, and C. D., aged 24, a former member of the R.A.F. Kinloss Mountain Rescue Team, were members of an eight-man team training for an expedition to Mount Kenya. Six of the men left Helyg at 08.50 hours on 17 November 1962 to climb on Craig yr Ysfa. They split in two parties of three each. A. B. and C. D. were in the same party. They climbed until 14.15 hours. There was much snow on the ground, and after being forced back in a gully they retraced the route they had taken in the morning. While they were returning to Helyg, A. B. became increasingly exhausted, and when they were three-quarters

of the way back he had to be supported by his companions. Three-quarters of an hour later C. D. also became exhausted and could no longer help to support A. B. Within sight of Helyg and the lights of Gwern-y-Gof Isaf farm A. B. collapsed. C. D. was too weak to go on alone for help, so the third member of the party, E. F., leaving his torch and rucksack with them and telling them to flash the torch and eat some food, went on to Helyg. He arrived 10 minutes later, and immediately set out with a rescue party. By this time it was blowing a blizzard and the tracks were soon obliterated. They failed in their search and returned for more help. There was some delay in contacting rescue teams, but the search was continued through the night. C. D. and A. B. were found dead in the morning.

The following quotation from a statement by E. F. is informative. "As we got further down the spur, conditions underfoot became more difficult. The snow was drifting in places to a depth of 2 feet, with marshy ground underneath. The weather also worsened again, with heavier snowfalls and a stronger wind. Our progress became much slower, and each one of us fell at times into the drifts. We crossed over a wall, and shortly afterwards, when I looked round to see if the others were following, I noticed that A. B. would sit for a few seconds before getting up after falling. I said to him, 'We must hurry up—don't sit in the snow.' After he had done this three or four times he complained that he was feeling weak, and I could see that he was walking unsteadily. I then told C. D. to support him on one side while I supported him on the other. As he came towards me I saw that he was wearing no gloves. He told me he had dropped them. While we supported him with his arms over our shoulders we each held one of his hands to afford him some protection. We progressed like this for about 10 minutes, when to my horror C. D. said he felt weak and could not continue to help me to support A. B. I thought their weakness might be due to hunger, so I made them eat some Kendal mint cake which I had in my anorak pocket."

Incident 11

A. B., aged 16, was training for a Duke of Edinburgh's gold award medal, having already won a silver award. On 21 February 1961 he set off on a 30-mile (48-km.) ramble in the Radnorshire hills with two friends, C. D., aged 16, and E. F., aged 18. All three were overcome by exhaustion or exposure. E. F. was the first to be affected, then C. D. collapsed. A. B. went for help but died in the attempt. His body was found only 400 yards (360 m.) away from the place where C. D. was rescued. The other two boys survived. The coroner remarked that the boys had made a fatal mistake by splitting up.

Scotland

Incident 12

On 29 December 1951 a fit party of four men and one woman set out at night from Carson's Lodge to cross the pass to Ben Aldon Lodge on Loch Eriech. It was a calm dark night with slight snowfall. The altitude was approximately 1,200 feet (365 m.). They were inadequately clothed, especially below the waist. Two and a half miles up the glen three of the party got tired and camped. The two others went on, but the snow was deep and they camped half an hour later. Next morning a gale was blowing. Both parties set out and met at about 09.15 hours. They tried to return to the first camp. One had to be helped—he died half a mile from the bivouac; half a mile further on two others collapsed. The woman stayed with them two hours until they died. The fourth man who had gone for help died half a mile farther on. The woman survived unhurt. This case illustrates the short time between collapse and death, and the survival of a woman when four men died.

Incident 13

Five fit and experienced climbers from Lancashire, aged 18 to 20, camped on Ben Nevis on 24/25 December 1956, intending to climb the mountain by South Castle Gully. They spent the next day climbing, but were delayed, and it was dark by the time they reached the summit. A blizzard was now blowing, and two of the party were exhausted. They spent the night in a shallow

depression but could not escape the wind. However, they survived and next morning one of them went down to fetch help. On arrival he was unable to describe accurately the position of his companions, and his memory of recent events was vague. Another member of the party attempted to descend that morning and was found dead at the bottom of a cliff. Two rescue parties set out that day and failed to find the casualties. Their three bodies were eventually found on the following day. They were wearing anoraks, knee-breeches, and stockings, and their clothes were wet through.

Incident 14

On 20 December 1961 four men, aged 23 to 26, set out from the top of the Cairngorm ski lift (3,000 feet; 910 m.), leaving no word of their plans. They went over Cairngorm (4,000 feet; 1,219 m.) and down to the shelter stones near Loch Avon, intending to spend the night there. They had no sleeping bags but were warmly clad and had a primus stove and plenty of fuel. However, they got wet through and at 18.00 hours decided to return to the car park. In spite of map and compass they got lost and wandered all night at around 4,000 feet (1,219 m.). One man, A. B., was "in a bad way" and an attempt was made to lower him down one of the corries on a rope. The rope slipped off a belay and he and another (C. D.) rolled down 200 feet (61 m.), but without injury. The other two went for help and came upon a three-man party of skiers in tents. With their help the alarm was given and rescue operations started. At 02.00 hours next morning A. B. was found lying in the snow but conscious. C. D. was still on his feet. A. B. was admitted to hospital suffering from exposure, shock, and frostbite. But for the chance meeting with the skiers both would have lost their lives.

Incident 15

This accident happened during an ascent of Cairngorm on 30 October 1962. An Outward Bound party led by instructors left Fairndouran Lodge at 07.50 hours, reached the saddle of Cairngorm at 10.15 hours, and the summit around 11.15 hours. By this time A. B., aged 18, was lagging behind. He said he had hurt his ankle. The party rested on the summit for some time. On the way down A. B.'s companion took his pack and helped him. They reached the upper ski-lift station (3,000 feet; 914 m.) at 13.00 hours, only to find it shut. By then A. B. was fuddled and vague. Shortly afterwards he collapsed and was taken down on a stretcher to the lower station. While on the stretcher they carried him feet down; he had a convulsion and a block of wood was placed between his teeth. Breathing ceased two minutes later.

The findings at the necropsy were as follows: moderate oedema of the extreme upper part of the larynx but no obstruction of the respiratory passages; some congestion of the trachea and main bronchi, and a notable degree of collapse of both lower lobes, the right middle lobe and the posterior parts of the upper lobes; no evidence of pneumonia but some muco-purulent exudate in the trachea and bronchi. Histological examination was confirmatory and showed no evidence of myocarditis. Cause of death was laryngeal spasm, vagal inhibition of the heart. This boy was thin. His height was 5 feet 8 inches (170 cm.) and his weight was 130 lb. (58.9 kg.). According to the warden's report weather conditions on the hill were cold and windy with plenty of blown snow.

Incident 16

21 May 1964. A. B., an exceptionally tall thin lad, was with a party walking on Cairngorm, near the summit. His instructor noticed he was starting to grumble and moving erratically. On reaching the summit he started to take off his anorak and sweaters. The temperature was just above freezing point and there was mist and a high wind. The instructor immediately started to take his party down. The weather cleared and by the time they reached Glenmore A. B. had fully recovered.

Incident 17

10 April 1965. A party of 15 Army cadets were taken by lorry to points 10 to 12 miles (16 to 19 km.) from their base and had to find their own way back. The route entailed passing over the

top of a mountain 3,900 feet (1,188 m.) high. The weather was warm and sunny. The leader, aged 21, had five years' experience in the hills. The boys wore Army windproof outer garments and two pullovers; each boy carried a spare pullover. They also had food with them.

One of the three groups, six in number, had just reached the top at 14.00 hours when bad weather suddenly blew up—hail, rain, wind, and freezing mist. The party forsook the direct route down and took an easier route to the valley. Two hours later the youngest boy, aged 16, was feeling unwell; he was assisted by the leader, who sent the others ahead and himself carried him for about a mile. The boy lost consciousness, and the leader decided to leave him. By this time another member of the group, aged 18, had expressed a wish to stop; he was made comfortable on the path some 5 miles (8 km.) from base. The leader came on past him but later himself collapsed on the path. The remaining three boys met a local policeman who accompanied them to camp. A rescue party set out at 23.00 hours. The leader was found at 01.00 hours and recovered; he had been unconscious but had revived. The boy on the path was given mouth-to-mouth respiration but did not come round. The third boy was found dead at 02.00 hours, 200 yards (180 m.) off the path. The other two parties had returned safely by 18.30 hours and 19.00 hours.

Cumberland and Lancashire

Incident 18

On 2 January 1953 two young men set out to spend a night on Scafell Pike. They got caught in a blizzard and were benighted. One lost consciousness about 01.00 hours and died soon after. His clothes were wet through. The other got down safely.

Incident 19

On 11 April 1960 an Outward Bound party in charge of an instructor set out from Eskdale on an exercise. The weather was fine and the party camped after an easy walk. Next day they were pinned down by heavy rain and gale-force winds. The bivouacs were washed out. After an uncomfortable night they set off at 08.00 hours to return to the school. At 09.30 hours A. B., a boy weighing 224 lb. (101.6 kg.), was showing signs of exhaustion and the instructor decided to take him down, leaving his party in charge of C. D., with instructions to proceed over Scafell Pike. The instructor had anticipated rejoining the party later on. It seems that C. D. led the party far too fast. Soon two boys were left behind and the patrol had to go back for them. About this time C. D. lost energy and made no more decisions. Two others took over and decided to get off the mountain by the shortest possible route. On their way down they lost their way and a young woman redirected them. It was then about 14.30 hours. By this time C. D. could no longer walk by himself. Some of the boys were sent on to fetch assistance. Three others remained to help C. D. but soon began to feel exhausted. One of them, E. F., became disorientated and very weak. A rescuer reached them at about 18.05 hours. First aid was given to C. D. and E. F. C. D. was unconscious and was later given artificial respiration. By the time the rescue party reached a farm C. D. was dead. E. F. recovered.

The necropsy report on C. D. was as follows: Age 18, height 6 feet 6 inches (198 cm.), weight 147 lb. (66.6 kg.). Clothing: long thick trousers, underpants, shirt, sweater, anorak, thick gloves, socks, shoes. The body was almost devoid of fat, but there were no other significant abnormalities. In this case the boys were tired on starting out; for a time they walked too fast. At that time no satisfactory oversuits were available. Symptoms were: peculiar behaviour, mental apathy, slowing down, disorientation, cramp. The boy who died was exceptionally tall and thin.

Incident 20

In 1961 on Scafell a man and woman bivouacked in Piers Ghyll. The man died and the woman survived.

Incident 21

In 1961 a girl, aged 15, survived when her two brothers, aged 11 and 18, collapsed and died on Bleasdale.

Incident 22

In December 1963 a rescue party from the Ullswater Outward Bound School rescued two 14-year-old boys, members of a party of Oxfordshire schoolboys who had been sent out walking in the hills in groups of six without instructors in extremely bad weather with gale-force winds. On arrival at the youth hostel the first boy to be brought in was unconscious but moaning. He seemed close to death, so Squadron Leader Davies, the Outward Bound warden, immersed him fully clothed in a hot-water bath. While in the bath the boy seemed to have a convulsion; he was then transferred to a warm bed. 35 minutes later he recovered consciousness and was talking rationally. By the next day he had completely recovered. The second boy was semi-conscious on arrival and was treated in the same way. It was noted that the water temperature had fallen to 106° F. (41.1° C.) before transferring him to bed. The initial temperature was not recorded but the water was "hotter than a normal person can stand."

Derbyshire*Incident 23*

This incident occurred on the Four Inns Walking Competition in March 1964. This competition is organized by the Derbyshire Rover Scouts and has been held annually for the last seven years. During the 1964 event there was an unforecast deterioration in weather, as a result of which at least seven competitors were affected by exposure and were rescued or assisted, and there were three fatalities. The incident has been described in detail in a previous communication. The main features were: (i) Unexpected change of weather. (ii) Inadequate clothing for conditions encountered. (iii) Short interval of time between the onset of symptoms and collapse. (iv) Adverse effect of a long evacuation by stretcher. Two of the dead youths were unusually thin (Pugh, 1964).

Statistical Summary

There were 11 incidents from Wales, 6 from Scotland, 5 from Cumberland and Lancashire, and 1 from Derbyshire. This distribution does not necessarily reflect the incidence of exposure accidents in the various regions, and we have no means of estimating the population at risk in each district. The incidents were equally distributed between private parties and organized parties from the armed Services, youth movements, or schools (see Table). Fourteen out of the 23 incidents occurred in the winter months, 2 in the summer, and the remaining 7 in spring and autumn.

Exposure Incidents Occurring in Private Parties, Parties from the Armed Forces, Schools, and Youth Organizations

	Private Parties	Armed Forces	Schools	Youth Organizations	Total
(1) Number of incidents ..	11	2	5	5	23
(2) " " persons at risk ..	33	14	53	?	100*
(3) " " persons unconscious, survived ..	1	—	4	—	5
(4) Number of deaths ..	14	3	2	6	25
(5) " rescued and treated for exposure (excluding (2)) ..	3	2	4	9	18

* Excluding youth organizations.

Causes

All the recognized causes of exposure accidents are represented in this series. They are:

(1) Weather conditions. Setting out in extreme weather conditions (Incidents 2, 7, and 22) or being overtaken by bad weather (Incidents 3, 4, 6, 13, 17, 23), especially blizzards. Blizzards imply temperatures at or below freezing point, high winds, and low visibility: in five examples (Incidents 6, 10, 12, 13, 18) there were 11 deaths among the 20 persons at risk.

(2) Being benighted. In Incidents 1, 6, 10, 13, 18, parties pushed on to exhaustion and were out all night; there were

8 deaths among 19 persons at risk. In these circumstances fatalities may occur even in the summer months (Incident 7). Except in the severer climate of the Scottish mountains, persons spending a night in the open survived if they took shelter before becoming exhausted, even if they were wet through. The hazard of camping out in the colder months without equipment of proved adequacy is illustrated by Incidents 5, 12, 14.

(3) Being wet through, or having otherwise insufficient clothing. There was a definite history of being wet through in Incidents 1, 3, 5, 8, 9, 18, 22, 23. The weather conditions and clothing worn justify the inference that most other casualties were also wet through. Inadequate protection against wind, at least over the lower half of the body, was a feature common to all the clothing assemblies recorded.

(4) Exhaustion. Physical exhaustion was a contributory factor in all the more serious cases. There was a history of muscular weakness in some cases (Incidents 5, 8, and 10), suggesting that cooling of the active muscles may be an element in exhaustion in these cases.

(5) Subcutaneous fat. In Incidents 15, 16, 19, and 23, the casualties were unusually thin.

(6) Sex. Females survived while their male companions died in Incidents 12, 20, and 21, and Incident 4 is an example of exceptional survival in a woman.

(7) Inexperience and lack of training. Errors of judgment due to lack of experience and possible inadequate fitness were factors in Incidents 1, 2, 6, 7, and 22. On the other hand, Incidents 3, 10, and 13 are examples of accidents happening to exceptionally fit and experienced parties.

Signs and Symptoms

With minor variations the sequence of events was as follows: abnormal behaviour, slowing, stumbling, weakness, repeated falling, collapse, stupor, unconsciousness, death. Associated features sometimes present were: cramp, loss of sensation in the legs, paralysis, and convulsions. Visual disturbance was present in two mild cases not included in the series; in both instances the circumstances suggest glare conjunctivitis.

Shivering was not a prominent feature of the more serious cases. That is to say, it was not specifically mentioned in the histories. On the other hand, less severely affected persons described violent shivering (Incidents 3 and 9). In experimental hypothermia shivering ceases at rectal temperatures below 34 to 35° C. and is replaced by generalized muscular rigidity (Dill and Forbes, 1941; Alexander, 1949). The latter was specifically mentioned in the case of one of the scouts involved in the Four Inns Walk incident, and in the two unconscious boys rescued by the Ullswater Outward Bound School.

Convulsions occurred in two unconscious patients being transported in the head-up posture (Incidents 15 and 23; Pugh, 1964) and in one during treatment in a hot bath (Incident 22). Postural hypotension may have been implicated in the boy being carried down by his leader in Incident 17, and may have hastened death.

Clinical Findings

On examination the clinical findings in patients admitted to hospital with exhaustion or mild exposure or both were virtually normal. Body temperatures, where recorded, were within normal limits, and there were no findings suggestive of circulatory failure. Deeply unconscious patients (3 cases) were described as being cold to the touch, but body temperature was either not recorded or stated to be unrecordable with a clinical thermometer.

The usual findings were: extreme pallor, generalized rigidity, and absence of peripheral pulses. In Incident 5 respiration was

barely perceptible, and the patient appeared to be dead. On the other hand, in Incident 2 stertorous respiration, exaggerated tendon reflexes, widely dilated pupils, and, in the recovery phase, resistive stupor were described.

Necropsy findings, like the clinical findings, were meagre. Four out of six corpses examined had little subcutaneous fat (Incidents 15, 19, 23). Abrasions and scratches consistent with repeated falling were usually present. Respiratory infection was thought to have been contributory in one case.

Mental Function

Most patients who were followed up mentioned apathy, sometimes preceded by a phase of anxiety. Two patients described feelings of unreality and detachment and one mentioned feeling as though he were slightly drunk. The companions of persons suffering from incipient exposure or exhaustion reported irrational behaviour, irritability, aggressiveness, or unusual silence and apathy.

Discussion

Environmental Factors

Most incidents in this series occurred in wet-cold conditions. Temperatures were close to freezing point; winds were strong or of gale force; and the persons affected were wet through. Casualties also occurred under warmer conditions—at temperatures perhaps as high as 10° C.—if the other factors of wind and wetting were present and the clothing worn was unduly light.

In the Cairngorm and Grampian mountains large areas of country are situated at heights over 3,000 feet (914 m.). In these regions mean temperatures are at least 8° C. lower than in London (5° C. reduction due to altitude and 3° C. due to latitude). In the colder months temperatures are often low enough (*viz.*, -5° C.) for the wetting of clothing and footwear not to be a problem. Nevertheless, three out of four incidents from Scotland occurred in wet-cold rather than dry-cold conditions, suggesting that wet-cold is the more dangerous condition even in these regions.

Clothing

The clothing worn by hikers and climbers conforms to a general pattern, examples of which are given in the case histories. Even with extra sweaters it is doubtful if more than 2 Clo units of thermal insulation can be obtained with these outfits, since military cold climate assemblies in the last world war, which weighed over 20 lb. (9.1 kg.), had insulation values of only 3 to 4 Clo units (Breckenbridge and Woodcock, 1955). In a companion paper experimental results are reported on the clothing worn by one of the youths who died on the Four Inns Walk in 1964 (Pugh, 1964, and Incident 23). The insulation value of this outfit was 1.5 Clo units. When saturated with moisture and in the presence of wind, the insulation value fell to 0.15 Clo units, a much lower value than had been predicted (Pugh, 1964).

Jeans and similar trousers are commonly worn by hikers, but climbers more often wear cord breeches and stockings, which give better protection, especially against wind. The anoraks commonly available to the public are showerproof but will not resist heavy rain or wet snow indefinitely.

The primary deficiencies of currently accepted clothing are, therefore, (i) lack of protection against wetting, and (ii) insufficient insulation and resistance to wind penetration over the legs. There is no doubt that correction of these deficiencies

would do much to reduce the incidence of hypothermia in this age group.

Subcutaneous Fat

The association between subcutaneous fat and resistance to body cooling in water has been convincingly demonstrated (Pugh and Edholm, 1955; Keatinge, 1960; Daniels and Baker, 1961; Rennie *et al.*, 1962). On the other hand, evidence from studies on cold-adapted social groups or individuals (Hammel, 1964; Pugh, 1964) do not support the view that subcutaneous fat plays an important part in cold resistance in air at low temperature. However, when a person's clothing is wet through, especially in the presence of wind, he is in much the same situation as a person in water at a somewhat higher temperature, and subcutaneous fat may then be decisive. This aspect is discussed in a companion paper (Pugh, to be published).

The case histories support the view that subcutaneous fat is important in this type of situation; in four out of six cases in which necropsy findings were available the bodies were exceptionally thin; and two examples are given of females surviving when their male companions died, the most probable explanation being their thicker subcutaneous fat.

Cold Stress and Exhaustion

When cold stress, fatigue, and discomfort are combined, the point of exhaustion is reached earlier than when they operate singly. In the Four Inns Walk in 1964 most casualties occurred when only 16 miles (26 km.) of the 45-mile (72-km.) route had been covered and 5 to 6 hours after the start. In 1965, under warmer conditions, many teams showed mental impairment and severe fatigue, but only after 30 miles (48 km.) had been covered and 10 hours after the start (Cooper, Johnson, and Pugh, to be published). Many incidents in the present series, in particular Cases 1, 6, and 9, illustrate the same point. Accidents occurred on trips that would have been considered easy in fine weather. Symptoms usually began about 6 hours after setting out, and occasionally within 1 to 2 hours of the onset of bad weather. The time interval between first symptoms and collapse was sometimes as little as 1 to 2 hours, and death followed after a variable period of 2 to 6 hours.

There are a number of obvious reasons for increased fatigue in severe weather conditions, the chief being perhaps the effort of fighting against gale-force winds.

An important contribution to this subject was made by Adolph and Molnar (1946), who studied nude subjects at rest and performing standard ergometer exercise in the open air over a wide range of meteorological conditions. The subjects worked at a rate they could maintain for 3 to 4 hours under comfortable conditions—namely, 380 kg./min.

During severe cold stress, at temperatures of 2 to 4° C. and wind velocities of 3 to 7 m.p.h., they became exhausted and stuporose within 1.5 to 2 hours, both at rest and during exercise. Mean skin temperature fell to 15° C. at rest and 17° C. during exercise, but rectal temperature did not fall below 36° C. at rest and 36.9° C. in exercise. Exhaustion was therefore not due to reduction of deep body temperature.

Metabolism during exercise was found to be 30% higher than it was during the same work under warmer conditions. Resting heat production, as a result of shivering, rose to levels comparable with those observed during exercise.

Adolph and Molnar (1946) considered that these high levels of energy expenditure explained early exhaustion in their subjects, but they were also impressed by the possible role of the physical discomfort associated with cold stress, and suggested that intense nervous stimulation created a critical state in the central nervous system leading to a breakdown of regulatory mechanisms. Direct evidence of this was, however,

lacking. The low skin temperatures of 15 to 17° C. observed by Adolph and Molnar (1946) suggest that local muscle cooling may have been a factor in exhaustion in their experiments, since muscle cooling may cause extreme muscular weakness in thin subjects swimming in water at these temperatures (Pugh and Edholm, 1955). An investigation of this aspect is being undertaken.

Mental Effects

Mental symptoms similar to those described in the case histories (see also Adolph and Molnar, 1946) may be observed in states of extreme fatigue, in situations where body cooling can be ruled out (Cooper, Johnson, and Pugh, to be published). The persons affected may lose their resolution and cease to go on taking measures necessary for their safety. They tend to wander aimlessly and get lost, fall down snow slopes or cliffs, fail to take shelter or find their way down to safety. Thus mental impairment alone may start a chain of events leading to fatal accidents in which death from hypothermia or injury are the end results.

Prevention

Clothing

As already suggested, waterproof overgarments would prevent most exposure casualties. Trousers, anoraks, and mackintoshes made of plasticized nylon are cheap and readily available. Though less suitable for regular wear than heavier protective garments, they are ideal for emergencies because of their lightness and small bulk. The Outward Bound movement have made important advances in this field. Reserve clothing should be carried in a plastic bag and should include trousers as well as sweaters. The value of such reserve clothing will, of course, be limited unless further wetting can be prevented. The difficulty of finding casualties both by day and by night suggests that bright coloured clothing would be preferable to dull colours that merge with the surroundings, and that hill walkers and climbers should always carry torches.

Shelter

Physiological reasons for taking shelter rather than pushing on to exhaustion are examined in a companion paper (Pugh, 1965, to be published). However, parties that cannot keep dry will be in serious danger at temperatures near freezing point unless they can either get off the mountain in time or set up a camp.

Camping

When a person shows early symptoms of exposure, the surest way of preventing disaster is to camp. The objections to carrying camping equipment are the extra weight and the expense involved. There is an urgent need for the development of light-weight and inexpensive emergency equipment for such parties.

Physique

Variation in capacity for physical exertion as well as other factors, such as limb length and subcutaneous fat, probably accounts for the fact that one member of a party usually fails before the others. The possibility of infection or illness should

not be disregarded. In some youth movements boys do not select their own companions but are randomly grouped, and it should be borne in mind that the spread of physical working capacity may be too wide to be safe. Grouping by exercise history is perhaps the simplest safeguard.

Treatment

The evidence is that unconscious or nearly unconscious patients revive spontaneously whatever treatment is administered once further cooling has been prevented. For field emergencies spontaneous rewarming seems to be the safest, if not the only, practicable treatment. The Four Inns Walk incident showed clearly the danger of long evacuation by stretcher, and consideration should be given to rescue parties setting up camp and reviving casualties on the spot rather than attempting to transport them long distances. The danger of carrying patients in a head-up position is emphasized.

After rescue, the hot bath treatment will reduce the duration of hypothermia and is certainly the treatment of choice for the conscious patient. The postural manipulation involved may, however, be dangerous in the unconscious patient. Cooper (personal communication) has shown that the rapid rewarming of hypothermic patients without a fall in blood-pressure by immersing both hands in hot water is a possibility. In the unconscious patient this might be a safer method than the hot bath treatment.

Summary

Twenty-three exposure incidents in various parts of Britain are described. There were 25 deaths, 5 cases of unconsciousness with recovery, and 58 milder cases. Most cases occurred at temperatures near freezing point and in the presence of gales, wind, or snow, wet-cold conditions being more dangerous than dry-cold conditions.

Wet clothing and walking to the point of collapse were the two principal factors in fatal cases. Symptoms began usually 5 to 6 hours after setting out. The interval between onset of symptoms and collapse and between collapse and death was variable, but might be as little as 1 to 2 hours respectively.

Convulsions occurred in two unconscious patients being carried in the head-up position.

Casualties could be prevented and lives saved by wider use of: (i) emergency dry clothing and waterproof overgarments, (ii) light-weight emergency camping equipment.

It is suggested that the safest treatment of such casualties, whether by other members of the same party or by rescuers, is to camp and allow the patients to rewarm spontaneously before moving them, unless the distance is short.

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