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ON THE NATURAL HISTORY OF FALLS IN OLD AGE*

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The liability of old people to tumble and often to injure themselves is such a commonplace of experience that it has been tacitly accepted as an inevitable aspect of ageing, and thereby deprived of the exercise of curiosity. The literature, in fact, on what has always been a trial for the elderly and is now becoming a problem for the community is very meagre (Sheldon, 1948; Scott, 1954; Droller, 1955; Hobson and Pemberton, 1955; Howell, 1955; DeLargy, 1958; Boucher, 1959; Exton-Smith, 1959; Fine, 1959), and bears little relation to either the practical importance or the intrinsic interest of the subject. An essential preliminary to further investigation is a knowledge of what actually happens, and the present paper is an attempt to meet that need by an account of the natural history of these falls.

The inquiry was directed at old people living at home, since the hospital population of old age has a heavy pathological bias, and, in addition, faces postural risks different from those of the community at large. This paper presents the results of an inquiry into 500 falls which happened to 202 individuals—86 had been brought to the casualty department of the Royal Hospital, Wolverhampton, as the result of a fall, 59 had been admitted with a fractured femur, and the names of 57 were provided by the practitioners of the town. The inquiry was stopped when 500 falls had been described. This number is much less than the total falls sustained by these individuals, and reflects merely the number for which reliable information was available. Of the 168 persons seen at home, 34 were men and 134 women. The age distribution of the 202 was as follows: 50–59, 11; 60–64, 16; 65–69, 27; 70–74, 35; 75–79, 39; 80–84, 53; 85+, 21. The frequency of the condition, its association with increasing age, and the ease of obtaining contact with a large number of old people so affected are obvious.

It proved surprisingly easy to classify the 500 falls, though the categories are not entirely self-contained.

Accidental falls	171
Drop-attacks	125
Trips	53
Vertigo	37
Recognizable C.N.S. lesion	27
Head back	20
Postural hypotension	18
Weakness in leg	16
Falling out of bed or chair	10
Uncertain	23

The very small number of falls out of bed is remarkable, and is in immediate contrast with their predominant importance in the hospital population of

old people (Fine, 1959), where the incidence of physical and, particularly, of mental defect is so much greater. The environment contributed a quota to the causation of 224 falls, whereas the cause lay within the old person in the remaining 276, though effective separation is difficult. Thus, while in some of the accidental falls a younger person would also have fallen, in many others balance would have been retained; for old people complain bitterly of inability to preserve their balance as they did when younger, saying, "Once you're going you've got to go"—a remark which reveals a considerable problem in defective physiology.

Accidental Falls

There were 171 falls (34% of total) in 125 individuals, as follows:

On stairs	63
Missing last step or steps	15
Poor illumination	13
Vertigo	12
Various	23
Slipping	49
Falling over unexpected objects	16
Dark	12
Various causes	31

One-third of falls sustained by old people living at home are accidental in origin, and are of importance in that they offer the main target for prevention. Stairs, in turn, account for one-third of the accidental falls, and the complete contrast between this fact and the small amount of time actually spent at risk is a measure of the great hazard that stairs present to old people. The most frequent cause lies in missing the last step or the last group of steps in the mistaken belief that the bottom has been reached. This happens to us all from time to time, but in earlier years we are almost invariably able to preserve our balance, even if with some difficulty, and it provides a good illustration of the difficulty experienced by the older person in preserving a balance suddenly placed in jeopardy. Not only did one-quarter of the falls arise in this way, but six of the 59 fractured femurs (10%) were in this group. The elimination of this particular hazard of the stairs is therefore a matter of urgency.

Next in importance comes inadequate illumination, whether the reason be defective vision or a fault in the actual lighting. In this respect the cellar steps and upstairs landings are especially apt to be at fault. Vertigo on the stairs accounted for 12 of the 63 falls. Some old people are apt to be giddy when looking down from the top of the stairs, but vertigo seems to be most dangerous when an individual is ascending, owing to the danger of falling backwards, with obvious risks of severe injury. There is need for improvement in the

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design of handrails for old people. Not only should they provide extra support at the top and bottom of the stairs, but the terminal shape of the rail should provide a special sensory cue which the hand will not normally reach till the feet have left the staircase at the bottom. A detached rail on both sides is ideal and should be of a size convenient for the sudden operation of the grasp reflex. The rail is often either so broad or so close to a wall that it is difficult for the hand to effect a sudden secure grasp in emergency. No fewer than 28 of the 63 falls on stairs might have been prevented by good handrails and adequate illumination, which in turn might have eliminated the further risk of the staircase, new to the old person, which was responsible for one-tenth of the falls on stairs.

Loss of balance on a slippery surface accounted for one-quarter of the accidental falls, and half of these (21 falls) were caused by ice or snow, the commonest mode being that of the old woman who slips on her doorstep or in the back yard after a frosty night. It was pointed out by Boucher (1959) that the death rate from falls in old age was at its highest in Scotland, and thence declined southwards from a figure of 2,854 women per million living to one of only 1,439 for the South of England. The frequency of falls on ice and snow would seem to offer a reasonable approach to this curious geographical difference in mortality.

In addition to the well-known risk of the mat on slippery linoleum, floors slippery from something spilt and rubber shoes on wet pavements were also a source of danger. The domestic risks entailed by objects on the floor in unexpected places (grandchildren and pet animals being mainly at fault) account for one-tenth of the accidental falls, and in many instances darkness or poor illumination was an important contributory factor. Indeed, the small number of accidents directly due to darkness (for example, a fall in a dark bedroom during the investigation of a noise because of suspicion of burglars) bears no relation to the importance of inadequate visual information as a hidden but potent cause of accidental falls. The effect reaches beyond actual avoidance of the incident: when balance is in sudden jeopardy the point of no return is reached much earlier in the old than in the young, and a deficit in visual signals may further impair this already narrowed margin of safety. The danger is often intensified by the simultaneous presence of postural hypotension, as in getting out of bed at night to pass urine. Under such circumstances, even the least visual aid, as by a nightlight, can be most helpful to old people.

Drop-attacks

One hundred and twenty-five of the falls, occurring in 58 individuals, were classified as drop-attacks. A similar incidence of one-quarter of all falls was found in the Wolverhampton survey of a random sample (Sheldon, 1948), and the confirmation of the important role of the drop-attack in the falls of old people is one of the main findings of the present investigation. They can be dealt with here in broad outline only.

In a typical attack the individual suddenly and without warning falls to the ground, and many such persons have emphasized that they were at their normal avocations and feeling in good health at the time. So unexpected and so sudden is the incident that there is no time to prevent or to break the fall. There is no loss of consciousness, though, particularly in more advanced years, the victims may be dazed by the shock of collision

with the ground, and are sometimes so surprised that they burst into tears.

Case 1.—A woman of 86 was in her scullery peeling potatoes. She felt nothing wrong at all, but just fell down. She had actually peeled one potato and had picked up a second when the next moment she found herself on the floor, with a potato in one hand and the knife in the other.

They appear to fall under the unrestrained pull of gravity, and the speed of descent is such that injuries are common; in fact, 26 of the 58 old people concerned had sustained fractures or dislocations, while lesser injuries, particularly cut knees, are still more frequent. If not complicated by injury, the pattern of recovery varies in a curious way, being either immediate or delayed. These are about equally common, and are illustrated by the two following case reports.

Case 2.—A woman of 61 was walking to church with a friend on each side when, as she says, she suddenly found herself on the pavement. Her friends were so surprised that they exclaimed, "Whatever are you doing down there?" However, she got up quite easily and went on walking. She appears also to have had some partial drop-attacks, for she "had been down on her knees three or four times."

The pattern of recovery in the next case was quite different.

Case 3.—A woman of 66 set out to go into town to do some shopping. She was walking along quite normally when, without warning, she suddenly fell forwards on the pavement. (She was not giddy, and knows that she neither slipped nor tripped.) She was quite unable to get up (though uninjured) and she had to remain some minutes on the pavement until a man appeared, when she managed to raise an arm to attract his attention. He, however, was quite unable to lift her, and, going off for help, was lucky enough to return with expert assistance in the shape of two dustbin men. With the additional help of a housewife who had just appeared, the four people were able to get her on her feet again. She stood where she was for a minute or so, and then managed to walk the short distance home with the woman holding her arm.

Several points arise from this history.

(1) Difficulty of Getting Erect Again

The difficulty of getting her erect again typifies the common experience of the younger relatives in these situations. They all agree that the patients are a "dead-weight," and there is little doubt that the loss of power is associated with a loss of muscle tone—a flaccid state.

(2) Distribution of Loss of Muscle Power

The distribution of this loss is peculiar. It certainly affects the legs, and there is good evidence that the trunk muscles are affected. A very intelligent daughter stated that the main difficulty in getting her father, aged 84, on his feet after one of these attacks was that of lifting his trunk, for "he has no strength in the body." It will be noted that Cases 5 and 7 (see below) fell on their backs and were unable to turn over, although it is clear from the details that the arms were unaffected. That the arms normally escape in the typical senile drop-attack is shown by the following case report, which is typical of many.

Case 4.—A woman of 79 was walking across the hall when she "suddenly went down wallop." She had the greatest difficulty in getting up, but managed to drag herself across the floor, and then "hoisted herself up by the furniture."

The histories show a remarkable agreement on the retention of sufficient power in the victims' arms to

drag themselves across the floor and clamber up a suitable piece of furniture—while the legs and the rest of the trunk remain flaccid. It is suggested, therefore, that the drop-attack is caused by a sudden loss of tone limited to the anti-gravity muscles normally concerned in the maintenance of the upright position.

(3) Duration of Loss of Power

The loss of power may be prolonged and of sufficient duration to endanger life in an old person living alone.

Case 5.—A woman of 80 had made herself a cup of tea in the kitchen, and had put it on the table when “down she went.” The kitchen clock registered 9.30 a.m. She fell on her back and could not get up until a neighbour came in at 5.30 p.m. She says the table moved whenever she tried to climb up it, and for the whole time she was unable to turn over on her face.

The duration of the loss of power for eight hours was cut short only by the timely arrival of help.

(4) Recovery of Function

We now come to what seems to me to be the most remarkable aspect of this whole series of events—that after, perhaps, some hours of effective paralysis, and after, perhaps, a considerable struggle to get the old person erect again—once there, immediate recovery of function occurs. In only one of the 125 falls did the individual fall down again after restoration of the upright position. Two case histories have provided a possible examination.

Case 6.—A woman of 72 “fell down flat” in her bedroom one night while going to bed. She was unable to get up herself, and her husband was also unsuccessful. She spent the night on the bedroom floor and was in some distress by the time the doctor was fetched next morning. He also found it impossible to lift her until he had moved her so that her feet pushed against the skirting-board of the room, when “he was able to lift her up from the back.”

Case 7.—A woman of 86 was at the back of a large ground-floor room, when she suddenly fell down. She was unable to get up again and had to drag herself on her back across to the front of the room so that her feet could fall over two low steps into the garden path. She was then able to grasp some railings and stand erect.

In both these histories there is the strong suggestion that the decisive factor in recovery of function lay in pressure on the soles of the feet. This recalls the “magnet response” or “positive supporting reaction,” which, according to Walsh (1957), is “obtained most readily in decerebrate animals that have been subjected to a removal of the cerebellum.” In this state pressure on the soles of the feet causes extension of the limbs and tensing of the back muscles. The analogy with what happens to these old people is too close to be accidental, and it is suggested that it is by the operation of this low postural reflex that tone is restored to the anti-gravity muscles and the higher centres in the hind-brain are enabled to resume their normal control of posture and gait. This, if true, leads inevitably to speculation on the nature of a disturbance of central function that can cause such sudden and specialized loss of power and can then be restored to normal by the evocation of a lower reflex. One wonders whether the drop-attack may be based on a sudden loss of postural alertness—a sort of postural inhibition or sleep—based perhaps on a disturbance of function in the reticular substance of the brain-stem.

Provocative Factors

In 96 falls with a good history the falls occurred during the following states of movement: walking normally, 36; turning round, 25; standing, 14; beginning to move, 8; rising from sitting, 8; throwing the head back, 4; out of bed, 1. The one fall out of bed seems to have been a true drop-attack, and is of interest in that it may be relevant to the frequency of falls out of bed in the hospital population of old people.

Case 8.—A woman of 81 was just beginning to get out of bed when she “suddenly found herself on the floor.” There was no giddiness. The recovery was typical, in that “she had great difficulty in getting up, and only managed this by dragging herself along the floor, and then up by the bed-rail.”

The circumstances in which the attacks occurred are so various that they must either be irrelevant or contain a common factor. If this be the case, the movement of the head and neck which in that particular individual affects the blood-flow in the vertebral arteries would seem the most likely cause. Sharply delineated as are the clinical features of the drop-attack, the falls of those who suffer from it are by no means limited to this mode. Fifty one of the 58 individuals had had more than one fall; 32 had had other types of fall, while 19 had suffered from drop-attacks alone. Thus in almost two-thirds of the victims the drop-attack could be regarded as but one manifestation of a more general decrease of postural control.

Trips

Trips were responsible for 53 falls in 41 individuals. In fact, many more than this number were sustained, for, of all the modes of fall, that by tripping was easily the most apt to affect certain persons with special frequency and for the details of earlier falls to be forgotten. Indeed, some of the old people concerned had come to accept this liability to trip as part of their normal existence. It seems to be directly associated with age, for half of these subjects were in the 75–84 decade, and they all agreed (1) that they did not lift their feet as high as they used to, (2) that they found it almost impossible to recover their balance once they had begun to go, and (3) they were more likely to trip when tired or in a hurry. As would be expected, the most frequent single cause is the edge of rugs and carpets. (“I collect all the mats,” said one old man of 84.) Kerbstones and steps in the house present a similar obstacle, and between them account for as many falls, while irregularities in the pavement are also a frequent stumbling-block. The underlying alteration in gait is obscure, but seems apt for experimental study. It may be part of the well-known gait of very old people, the “marche à petits pas,” which, as Critchley (1931) has pointed out, so strongly suggests an extrapyramidal origin.

Falls Due to Vertigo

These amounted to only 37 falls in 26 individuals. This number—a mere 7% of the whole series—is surprisingly small, for popular belief ascribes all unexplained falls in old people to an attack of giddiness. The reason is undoubtedly that the development of an attack of vertigo is usually slow enough to allow of safety measures—as by sitting down or holding on to something. For this reason only 26 of the 45 persons in the whole sample who were liable to giddiness had

actually sustained falls, and in 20 of the 37 falls it was obvious that there would have been no fall had there been something handy to catch hold of.

This mode of falling is of special importance in late old age, for rather more than half the group (14 out of 26) were in the eighties. In some instances the subjective giddiness was accompanied by a sudden act of rapid, compulsive, and uncontrollable turning, which brought the old person at once to the ground. It has already been pointed out that the most dangerous of the falls due to vertigo are those that occur when an old person is going upstairs. The incidence of defective hearing and of tinnitus was almost double that found in the whole sample, figures of 58% for defective hearing and of 41% for tinnitus contrasting with 29% and 20%.

Falls Due to Disease of Central Nervous System

Twenty-seven falls occurred among 21 individuals. One-tenth of the sample were therefore concerned, and in some cases the number of falls was large, though an adequate history was available only for the last one or two. The conditions found were: subacute combined degeneration of the spinal cord, 3; paralysis agitans, 3; onset of cerebral thrombosis, 4; probable carotid or basilar artery thrombosis, 4; pre-existing hemiplegia, 7.

Falls Due to Throwing the Head Back

Twenty falls in 17 individuals were the direct consequence of looking upwards with the head thrown back, and in 17 of these 20 falls the old people were working with the hands above the head. Falls due to this cause may begin in late middle life, but they become increasingly characteristic of the later stages of old age: 10 of the 17 individuals were beyond the age of 75. Typical cases were:

Case 9—A woman of 86 had been advised not to reach above her head, but nevertheless she went out to hang up some clothes on the line, and as she started to do so "at once went down with a wallop backwards."

Case 10.—A woman of 64 (who had had several drop-attacks) wanted to stitch a curtain at the top of a door and therefore stood on a stool while her husband held her. When she started to work above her head she was "seized at once with an attack of giddiness" and a "very queer feeling," so that her husband had to get her down. Had he not been there she would have had a nasty fall.

These falls carry a special risk of injury, for a common domestic reason for working with the head thrown back is to reach something high up in the room—such as an electric-light bulb—which may necessitate standing on a stepladder or a chair and so greatly reduces the security of stance. Many old people find that to retain balance with the head thrown back they need both to stand on a wide base and to hold on to something. When placed at sudden risk in this position old people are apt to clutch at whatever may be handiest, and so to bring some heavy object down on top of them.

Case 11.—A woman of 87 began to have falls if she put her head back and worked with her hands above her head. She had always kept her hats on the top shelf of a wardrobe, and in trying to reach them she pulled the wardrobe over on top of her on two occasions. On another occasion she brought down a heavy iron saucepan and narrowly escaped injury.

Many old people have discovered for themselves the dangers of this posture and never willingly adopt it.

The factors that may be concerned are undoubtedly relevant to the whole problem of falls in old age.

Falls Due to Postural Hypotension

Only 18 of the 500 falls were the direct result of postural hypotension—that is, of rapidly standing erect. Twelve falls occurred in the bedroom and four on straightening up—a particular hazard of the elderly gardener. The small number of falls ascribed solely to this cause bears no relation to its great importance in the postural life of old people, for many of them consciously adapt their habits to cope with it. Like inadequate illumination, postural hypotension has great importance as a hidden ingredient in other types of fall—as anyone will realize who has watched the initial uncertainties of balance of many old people when starting to move immediately after rising to the erect position. Of the 202 persons in the sample, 29 (14%) complained of postural hypotension, and had sustained 72 falls of various kinds.

Other Types of Fall

Of the remaining types of fall, 16 occurring in 12 individuals were due to mechanical weakness in one leg, so that it was unable to meet an emergency such as that caused by stepping on a loose stone. These falls, in general, were due to factors carried over into old age from earlier years, such as loss of muscle from an attack of poliomyelitis or the effects of trauma. The relative infrequency of falls out of bed or a chair—10 falls in six individuals—is in striking contrast to their importance in the hospital population of old age. These falls, which are often based on mental confusion, are always of serious import and apt to be terminal features. Finally, 23 falls in 21 individuals remained unexplained—a surprisingly small number.

Discussion

To venture beyond clinical description is at the moment hardly more than an adventure in speculation, for the clinical is almost the only evidence available. Nevertheless, the population of old people liable to falls seem to possess characteristics of much interest.

Defects of Function.—The incidence of defective hearing, tinnitus, and vertigo was identical with that found in the Wolverhampton random sample of 1948 (Sheldon, 1948), which suggests that these defects of function have no bearing on the general liability to fall. Droller (1955) confirmed this for vertigo in the Sheffield survey; for the incidence of fractures in old women was the same in those with and without vertigo.

Loss of Vibration Sense in the Legs.—This was found in 22 of 62 patients examined (35%), which is somewhat higher than the figure of 25% found in the Sheffield survey (Hobson and Pemberton, 1955). This is a well-known phenomenon of ageing, but it is unlikely to be of relevance here in view of Droller's (1955) analysis of the Sheffield figures, which showed that the incidence in those who fell was only 15.9%, as compared with 30.6% for the remainder of the sample.

Plantar Responses.—Of the 81 individuals examined 18 (22.3%) had abnormal plantar responses. These were absent in 2, extensor in 7, and equivocal in 9—the abnormalities being bilateral in 13 and unilateral in 5. The series is confined to those with no other evidence of pyramidal-tract defect. Howell (1949) found abnormal plantar responses in 5% of Chelsea Pensioners. In the

Sheffield survey (Hobson and Pemberton, 1955), after subjects with hemiplegia had been excluded, a similar figure of 5% was also found. The findings in the present sample suggest that abnormal plantar responses—without other evidence of pyramidal-tract damage—may be some four times as frequent as in the general old-age population. This confirms the findings of Droller (1955), who found in the random Sheffield sample that an extensor response was four times more frequent in those men who fell than in the rest (24%/16%); and in women it was almost twice more frequent in those who fell than in the rest (11.6%/7.5%). There is therefore good evidence that old people liable to fall have an incidence of abnormal plantar responses considerably in excess of that present in a random sample of old age.

Stability of Posture.—Stability of the erect posture was examined by Romberg's test in 65 individuals. In 16 (24%) there was a severe degree of Rombergism, the subjects being quite unable to remain erect with eyes closed, even when standing on a wide base; in 21 (32%) there was a moderate degree of Rombergism—with eyes shut the subjects maintaining a normal stance when on a wide base, but developing excessive sway with the feet together; in the remaining 29 individuals (44%) there was no Rombergism, balance being quite normal. More than half of the subjects tested, therefore, had a defective control of balance. No normal findings are available for comparison, but general experience would suggest that this incidence is much higher than the average incidence for the old-age population. It has a bearing on a severe deterioration of gait, which was present in 24 individuals. With an attitude of general flexion they walk with everted feet on a wide base, while holding on at the same time to the furniture or walls for further support. It is a truly senile gait, for of the 24 subjects concerned 23 were over the age of 70 and 18 were over 80.

Case 12.—A woman of 81—subject to innumerable drop-attacks—says she uses a stick to get about the house and holds on to anything near her hands for support—and it takes her a very long time to move around. To get out of her living-room she first holds on to the table, then to a chair, and then pulls on an old coat of her husband's which she keeps specially behind the door—while she opens the door and goes down one step into the kitchen; and so on.

Inability to Throw the Head Backwards Without Unpleasant Symptoms.—This was found in 41 of 81 individuals in the sample (50%), and in 16 of 27 (60%) of those subject to drop attacks—figures which are almost certainly much higher than in the general old-age population. The effects vary from a feeling of giddiness to a "very curious" or "very unpleasant" feeling, or to an immediate fall. It is unlikely that symptoms so immediate and so unpleasant result from the extra acrobatic skill necessary to preserve balance in this position; it is far more likely that the effective factor lies in the influence this position may exert on the patency of the vertebral arteries. Hutchinson and Yates have shown (1956) that the vertebral artery is particularly apt to be kinked by coexisting osteoarthritis of the cervical spine; and, since this is extremely frequent in old age, it is suggested that in the old people concerned the movement of the cervical spine involved in throwing the head back and looking upwards leads to kinking of one or both vertebral arteries, with resultant effects on the blood supply to the hind-brain. That this is likely to be the real explanation is borne out by the following remarkable case.

Case 13.—A woman of 57 says that she gets giddy if she holds her head back, and for this reason if she wishes to work at anything above her head she has to get her husband to steady her, especially if she is on steps. She added, however, that if she was by herself and really wanted to hold her head back, she could do it all right, but "it took her a little time to arrange her neck." Presumably the twisting movements of the neck that she used to illustrate this manœuvre were successful in freeing a portion of the vertebral artery that had been nipped by the extension of the neck.

Blood-pressure.—This was taken in 108 cases. The average figure for 22 men was 165/98, and for 86 women 182/103. These are in close agreement with the Sheffield findings (Hobson and Pemberton, 1955), and there is certainly no special incidence of hypertension in old people liable to fall. No information is available on whether changes in circulatory dynamics occur with any greater frequency than in the general old-age population.

Sex and Age Incidence.—The sex incidence shows a marked preponderance of women. The female incidence in the present sample is overweighted by the greater liability of women to fractures, but in the Wolverhampton random sample (Sheldon, 1948) 21% of the men were affected, as compared with 43% of the women. The steadily increasing incidence with age has already been pointed out. To sum up, the evidence suggests that old people liable to fall may differ from the general old-age population in the following ways: an increase in numbers with advancing age; a preponderance of women; and a greater incidence of pyramidal-tract damage, of defective control of posture, of associated abnormal gait, and of inability to throw the head back without symptoms.

Conclusions

On the whole, the evidence suggests that the different modes of fall are varying manifestations of a more fundamental defect in the control of posture and gait. The weight of evidence strongly suggests that this defect is central and that possible peripheral factors, such as muscular wasting or sensory defect, are unlikely to play more than an adjuvant role, so that the structural basis of the clinical picture is to be sought in the areas concerned in the central control of gait and posture, particularly the brain-stem and cerebellum. Evidence is available from other sources which supports this view and also incorporates the age factor, for, beyond any doubt, there is a fundamental relation between advancing years and increasing liability to fall.

It is well known that ageing is accompanied by a loss of nerve cells from the brain, and Bourne (1956) has summarized the numerical evidence of the rate of disappearance of Purkinje cells from the cerebellum with age. Not only does this reveal a severe neuro-cellular deficit in advanced age, but, in addition, special staining indicates loss of enzyme activity of the remaining cells. It is suggested, therefore, that the fundamental factor underlying the senile liability to fall is a decrease in the number of healthy nerve cells available for the control of posture and gait. Certain difficulties of movement which are common in old age become easier to understand on this basis: these are the difficulty in recovering balance once it has begun to be lost, and the way in which many old people have almost to think out an unusual movement before starting to execute it—as if the small number of cells available made it

necessary to lay down the sequences of movement in advance.

It is not known whether this neurocellular atrophy is a direct result of the ageing process or whether it is based on ischaemia. Biemond (1951) found disappearance of Purkinje cells as a minimal result in some cases of basilar artery thrombosis, and suggested that "slight interference with the circulation in the cerebellum may lead to a local and perhaps also a more diffuse disappearance of the Purkinje cells." These observations are particularly relevant in view of the fact that no less than 50% of the whole sample and 60% of those having drop-attacks were unable to throw their head back without immediate symptoms. Reasons have already been adduced for the view that this is based on temporary obstruction to one or both vertebral arteries facilitated by senile cervical osteoarthritis, and it fits in well with Kremer's (1958) suggestion that drop-attacks are based on transient changes in the blood-supply to the brain-stem. Relative ischaemia in the territory supplied by the vertebral and basilar arteries might also underlie the high incidence of abnormal plantar responses, and much of the vertigo of which old people complain so bitterly may have the same origin.

It is suggested, therefore, that the general insecurity of postural control and the liability to fall which are characteristic of old age are based ultimately on a decline in the number of nerve cells in the brain-stem, cerebellum, and other centres—below that available for the maintenance of normal postural function in earlier life. The adverse effects of this cellular poverty will inevitably be accentuated by interference with the blood supply to the region which, in two ways, is particularly apt to happen in old age—by the liability of the vertebral arteries to temporary obstruction and the general proneness to phases of hypotension based on postural and other causes. Many intriguing problems remain; the drop-attack remains a remarkable event—from its instantaneous onset to its apparent path of recovery in some cases by the initiation, through pressure on the soles of the feet, of a reflex which seems hitherto to have belonged more to the province of neurophysiology than of clinical medicine. Therein, however, lies one of the fascinations of old age as a clinical study, for these phenomena have been uncovered because at this stage of life Nature resembles the engineer who may release the unexpected when he tests his materials to destruction.

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SEROLOGICAL RESPONSES AND CLINICAL REACTIONS TO INFLUENZA VIRUS VACCINES*

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In 1956-8 the Medical Research Council Committee on Influenza and Other Respiratory Virus Vaccines carried out a serological trial with oil-adjuvant vaccines of various viscosities, and in 1958-9 a trial with vaccines admixed with different amounts of aluminium phosphate.

In planning the 1956-8 trial, consideration was given to the fact that in past trials the very efficacious oil-adjuvant vaccines produced severe local reaction in a small number of individuals (Philip *et al.*, 1954; M.R. 1955, 1957). It was thought that, apart from purely chemical factors, the degree of viscosity of the vaccines, or possible physico-chemical changes arising during storage, might play a part in the aetiology of these reactions. However, before attempting to discover the influence of these factors on reaction rates in a large-scale trial, it was decided to study, with small groups of volunteers, the serological responses to fresh emulsified vaccines of different viscosities and to the same vaccines after storage.

In detail, the object of the trial was then: (1) To compare the serological responses, and as far as possible to observe clinical reactions, to three oil-adjuvant influenza virus vaccines which differed only in viscosity, and to compare these responses with the response to a saline vaccine containing the same quantity of antigen. (2) To assess serologically and by clinical observation the keeping properties of these three oil-adjuvant vaccines after storage for four weeks at 4° C.

The purpose of the 1958-9 trial was to examine, in view of a slight risk of provoking poliomyelitis especially in children, the value of aluminium phosphate in saline influenza virus vaccines. In all the earlier trials of saline vaccines which have been organized by the Committee aluminium phosphate was a component of the vaccines. It was thought that aluminium phosphate had possibly an adjuvant effect in man and that this substance was, at least in part, responsible for the low rate of both the local and the general reactions observed with aluminium-phosphate-adsorbed vaccines.

To ascertain the validity of these suppositions, it was decided: (1) To study in a serological trial, with small groups of volunteers, the comparative adjuvant effect, if any, of 10 mg., 5 mg., and 2.5 mg. of aluminium phosphate per dose of influenza virus vaccine, using as a control a vaccine without aluminium phosphate but containing the same quantity of antigen. (2) To compare the clinical reactions to these four vaccines in somewhat larger groups of volunteers.

VACCINES

The vaccines used in both trials were prepared at the Wright-Fleming Institute by methods described

*A report to the Medical Research Council Committee on Influenza and Other Respiratory Virus Vaccines.