

The Causes and Prevention of Miners' Nystagmus.

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Miners' nystagmus is an occupational neurosis which is confined to workers in coal mines. The chief symptom and physical sign is a rotatory oscillation of the eyeballs, which prevents the miner from accurately fixing anything towards which his vision is directed. The result may be compared to a cinematograph exhibition, in which the pictures have not been taken rapidly enough to produce a continuous image, or where the film has been worn away by over-use, giving a blurred image.

Description.

The man first notices that he is unable to perform the more skilled part of his work; he cannot notch timber well, and fails to drive his wedge, or strike with his pick the exact piece of coal aimed at. He next complains that the lamps dazzle his eyes, that he is unable to see anything at night time, and, finally, that the lamps and all surrounding objects are going round and round. Headache, varying from slight pain between the temples to attacks of extreme severity, giddiness on exertion and stooping, night-blindness, dread of light, and in severe cases marked nervous depression (two

of my cases have expressed suicidal intentions), are all found in a marked case of nystagmus.

There are two distinct varieties of the disease, in the first of which the symptoms are absent or latent, and the man apparently suffers no disability. In the second group the man suffers more or less disability. Tables I and II, and a number of subsequent tables, are the result of an analysis of 400 consecutive cases which I have investigated up to the present time.

Table I.

Latent	43
Manifest.....	357

Table II.—Analysis of Symptoms.

Movements of objects	361		
Headache	305	Marked 38	Very marked in 16
Giddiness	308	„ 40	„ „ 7
Night-blindness	262	„ 4	
Photophobia	159	„ 9	

Physical Signs of the Disease.

Movements of Eyes.—These, in true miners' nystagmus, are of a rotatory nature, often irregular both in rhythm and extent, increased by exertion and by looking up, and diminished by looking downwards and inwards. The so-called lateral or vertical nystagmus is a rotatory one, with a large lateral or vertical excursion respectively. Both eyes are affected equally in the great majority of cases. I have seen well-marked movement in the stumps of very shrunk and useless eyes (Cases 15, 17). Rate, 80 to 500 a minute (Romiée (1), 120 to 500). Range of movement, 1 mm. to 1 cm. (Romiée (2)).

Movements of eyelids.—These are often marked, and, when present, render the detection of the nystagmus very difficult. This sign was present in 90 cases and marked in 17.

Tremor of the eyebrows, head, neck, and even of the shoulders, may also be present. Tremor of the head was present in 84 cases and marked in 22.

Stassen (3) suggests that the head tremor should be looked upon as antagonistic to the ocular movements, and designed to neutralise them. I think it should be regarded as a mark of extension of the disease. There is one very important sign to which sufficient attention has not been paid—the backward and often oblique position in which the head is held. This is

accompanied with drooping of the upper eyelids and convergence of the eyes. I regard this sign as one of extreme importance.

The eyes are often congested, and a convergent squint is frequently found. The power of fixation and accommodation is greatly weakened. The patient tires very quickly, and the visual acuity may drop from normal to half of normal in a few minutes. When movements are present, vision is rarely more than one-sixth of the normal.

Table III.—Frequency of the Disease.

	Per cent.
Romiée (1) and Nuel (4).....	20
Dransart and Famechon (5)	10
Court (1890) (6)	34·75 of coal cutters.
Stassen (3).....	21·7
Libert (7)	23·9
Rogers (8).....	17·5

All these figures are obtained by systematic examination of several thousands of workmen.

My figures refer not to the total number of cases of nystagmus, but to the number of men who were compelled to give up underground work for a time.

Table IV.

District.	Cases.	Underground workmen.
A	425	133,000
B	413	56,580
C	27	8,000
D	11	28,000
E	75	12,500
F	2	2,870
G	1	6,855
H	No known cases	5,437

G and H are naked-light districts, F is an anthracite district. B, C, D are almost entirely safety-light districts in which a considerable amount of holing is done. A is largely a safety-light district in which holing is the exception.

I am obliged to Dr. S. W. Plummer, of Durham, for notes of 10 cases which have come under his notice as certifying surgeon for his district. Dr. Plummer is unable to give me the proportion this number bears to the number of men employed, but as the cases are spread over a year the amount of nystagmus, at present, in the North of England appears to be small.

In the Blue books (ref. 9, 10, 11) on "Statistics of Compensation," the number of cases of nystagmus receiving compensation for the years 1910,

1909, 1908, are given as 1618, 1011, and 460. The great increase should be noted, and I believe it will be maintained for some years.

The following is the result of a systematic examination of 110 officials (chiefly firemen):—Nystagmus was found in 35 cases, eight of which were marked; 11 cases were doubtful; 64 cases were quite free. The visual acuity was tested in all cases, and even when 6/6 was reached the answers were, in many cases, given in a hesitating manner:—

	Nystagmus.	Doubtful.	Free.
Number	35	11	64
Mean age	42·3	39·8	37·1
Mean years of underground life	30	26·4	21·9
Vision—			
6/6—6/9	14	5	48
6/12 or less	21	6	14
Error of refraction—			
Hypermetropia	8	1	4
Astigmatism	8	2	4
Myopia	1	1	4
Degree of error—			
Less than 1 D	12	2	4
1 D and over	5	2	8
Colour of hair—			
Fair	12	2	6
Medium	9	4	13
Dark	14	5	45
Colour of eyes—			
Blue and grey	22	3	29
Light and dark brown	13	7	35

Cost of the Disease.

I have exact figures of the amount paid to 425 cases of nystagmus during one year. Taking this figure as a basis then the cost of the 1618 cases in the kingdom would be £31,853 in compensation for one year. That this figure is a reasonable one may be seen from the following table compiled from the Blue books quoted above (10, 11, 12):—

Table V.

Year.	No. of cases.	Increase.	Cost of all industrial diseases.	Increase.
		per cent.	£	Per cent.
1908	460	—	13,382	—
1909	1011	120	27,288	104
1910	1618	60	42,507	55

It will be seen that the increased cost of charges due to industrial diseases bears a similar rate of increase to that shown by nystagmus.

In addition to the compensation charges the employers lose the profit of the work done by these men, while the workmen lose a sum in wages which may well be double the sum quoted. In many cases the men are not able to earn as much during the 12 months preceding their failure to work.

Taking all these factors into consideration I estimate that there is a loss to the kingdom of at least £100,000 a year due to nystagmus.

Table VI.—Disability.

Back at old work	59 (43 latent)
Idle	216 (average length of idleness to date, 10·4 months)
Surface work.....	124 (average time spent on surface to date, 13·3 months)
Dead	1

Twenty-four cases tried to work underground and failed.

This table presents too dark a view for the following reason. My cases are taken from all over the country, and in many places it was only the worst cases that I saw.

Historical Account of Miners' Nystagmus and Theories of its Causation.

The first case was discovered by Decondé (12) in 1861. C. Bell Taylor (13) published a paper in 1875 on "Miners' Nystagmus, a New Disease," Alf. Graefe, 1873, Nieden (14), 1873, Dransart (15), 1877, were amongst the earliest observers. The chief workers since that date have been Snell (16), Court, Jeaffreson (18), and Reid (19), in England; Romiée and Nuel in Belgium; fellow workers with Nieden and Dransart in France and Germany.

Romiée points out (1) that the Davy lamp was recommended for use in 1851 (10 years before the first recorded case), and states that after the compulsory use of the Mueseler lamp in Belgium in 1876 the cases of nystagmus became more numerous. He says that our forefathers were at least as good observers as we are, and that if the disease had existed then they would have discovered it.

There are two chief schools with regard to the etiology of nystagmus. One, of which Romiée, Court, and Thompson (20) are the chief exponents, attributes the disease to the strain of excessive accommodation, the result of deficient light. The second school, to which Snell, Dransart, Nieden, and Nuel belong, attributes the disease chiefly to the position assumed by the collier, and thinks that there is a local myopathy affecting the elevator muscles of the eye.

Romiée brings forward very strong evidence in support of his theory. He

Table VII.—Age and Duration of Underground Work.

Average age at onset	40 years.
„ period of underground life before onset.....	26·96 years.
„ interval between onset and failure	11·14 months.

Occupation.

In this table figures are given as to the percentages of cases and of men employed in various ways in a steam-coal colliery. The latter data are taken from two Welsh steam-coal collieries employing over 2,500 men.

Table VIII.

Occupation.	No. of cases.	Per cent.	Per cent. of workmen in steam-coal pit.
Colliers and collier boys	337	84·25	60
Timbermen and repairers	29	7·25	8·7
Hauliers and haulage men	24	6	14·6
Rippers	3	0·75	2
Contractors and hard ground men...	2	0·5	7·5
Labourers	3	0·75	1·8
Under officials (firemen)	1	0·25	1·9
Hitcher	1	0·5	
			3·5 various

It will be seen that the men who work at the coal face are the class chiefly affected, but that no class of worker is exempt. It is interesting to note that the first two classes contain 91·5 per cent. of the cases. These men are the most skilled workers, and have to use their eyes more than the others.

The collier places each blow of his mandril accurately, or loses so much work. I have tested colliers by making a mark, the size of a half crown, on the coal with chalk. Every collier struck the mark accurately with the pick when I asked him to do so. The timbermen have to adjust accurately the pieces of timber used to support the roof, and the work is of a very skilled nature.

A few words on the manner in which the collier obtains his coal are necessary. There are, roughly speaking, three ways—

- (1) By holing.
- (2) By taking advantage of the cleavage lines of the coal.
- (3) By the use of mechanical coal cutters.

(1) Holing has been briefly described above. In thin seams, or when the coal is undercut beyond 3 feet, the collier has to assume a reclining position. In thicker seams the collier often kneels at his work, and then his vision is directed downwards.

(2) In thick seams, or where the pressure is great, one edge of the coal is freed and the coal forced out with a bar. In comparison with the last method little skill is required, except in the care of the roof.

(3) Coal cutters. Here the men are more like labourers and not skilled workmen.

Table IX.*

Much holing	111	} 209
Some „	98	
Little „	22	} 129
No „	107	

Table IXA.

Of the 111 cases holing was done :—	
On side	77
On knees	25
With body inclined.....	9

* This table applies to colliers only ; a few cases where the man had been a collier at one time are added.

Table X.—Figures given by Returns made from 43 Collieries (one district).

	Collieries.	Percentage of nystagmus.
Much holing	30	0·69
Little or no holing ...	13	0·79

Thickness of Seams.

The thickness of seam does not appear to be of great importance, but as I am unable to give the relative proportion of men working in the several seams my figures are not so valuable as they might be.

Table XI.—Thickness of Seams.

Less than 2 feet	1
2—3 feet	43
3—4 „	85
4—5 „	102
5—6 „	50
6 feet and over	72

Three men had worked with coal cutters.

Table XII.—Returns from 43 Collieries.

Seam.	No. of collieries.	Percentage of nystagmus.
Less than 3 feet ...	16	0·81
3—4 feet	14	0·54
4—5 „	14	0·80
5—6 „	5	0·58
Over 6 feet	6	0·41

In this table some of the collieries, having more than one seam, appear more than once. The thinnest seam I visited was at Radstock, near Bath, through the courtesy of Mr. G. McMurtrie. The seam was from 12 to 14 inches thick, and all work was done on the side. The pit was lit with candles and no case of nystagmus had been heard of in the district. I examined men at the face. All told me they had no trouble with their eyes and that they had never heard of the disease. There was one very slight case of nystagmus in a man who had worked in a steam-coal pit, but who assured me he had never had any trouble with his eyes.

Light.

The great difference between a coal pit and a metalliferous mine is that in the coal mine a safety lamp is often required. In the Cornish tin mines candles are used and no nystagmus is present.

In reply to a letter of mine Dr. J. Telfer Thomas kindly sent the following: "I have been in practice in the mining district of Cornwall for the past 23 years and have never seen a case of miners' nystagmus there. . . . It does not attack tin miners."

There is a great difference between the light given by a candle and that from a safety light. The candle gives more light, remains constant through the day, throws no shadows, and, most important of all, can be placed very much nearer the coal face. Some miners place the candle under the ledge of coal they are undercutting. The safety lamp gives less light, quickly becomes dirty, throws shadows, and must be placed out of reach of the pick. The bonnet and oil reservoir cut off much of the light and produce an area of darkness above and below the lamp. (Court lays stress on all these points.) My figures show as far as I am able to do so the relative percentages between the two classes of pits.

In Somersetshire and the Forest of Dean nystagmus is practically unknown. Both are naked-light districts. Through the courtesy of the Home Office I am able to give the figures for Scotland apart from those of the rest of the Kingdom.

I have made a table from these figures and from the Blue books (30, 31).

Table XIII.

	Scotland.	Rest of Kingdom.
No. of cases	55	1563
Percentage of cases to men underground	0·05	0·21
Percentage of safety lamps used (31).....	28·2	91·6

Nystagmus is four times more common in England and Wales and lamps are used more than three times more frequently than in Scotland. (All the Scottish cases may have come from safety-light pits.)

Table XIV.—(My Figures.)

	No.	Latent.	Receiving compensation.
Safety-light pits.....	392	38	354
Naked-light pits	8	5	3

I have drawn up another table in which I have separated my local cases from the rest. My complete figures represent a good average of the whole of England and Wales.

Table XV.

	England and Wales.		Rhymney Valley.	
	Men employed.	Percentage of nystagmus.	Men employed.	Percentage of nystagmus.
Naked lights	8·4 or 1	0·89 or 1	12 or 1	2·66 or 1
Safety	81·6 9·7	99·01 111·2	88 7·5	97·34 36·5

In England and Wales the percentage is 1 to 12·5, in the Rhymney Valley 1 to 5. Of the eight cases from house-coal or naked-light pits five had worked in safety-light pits; five were unaware of the fact that they had nystagmus.

Of the three cases who were bad enough to fail, one was so deaf that I could get no history, one had worked seven years with safety lamps, and the third (Case 6) developed nystagmus immediately after the shock following the Darran explosion, in which he was one of the survivors. He had no trouble with his eyes before.

Murton Colliery, Sunderland, is a very large colliery, and the only one in England where electric lamps have been extensively used for years. In reply to a letter of mine asking for information, Mr. Wood sent me the following:—"Nystagmus.—Our cases have been so few and far between that I have no information of value to give you." No comment is necessary.

In one district which I visited the men complained to me that the oil used in a certain colliery was very poor in lighting quality. I saw the

certifying surgeon of that district, and he told me that he had more cases of nystagmus from that small colliery than from all the other collieries around. In another district I had many complaints that the lamps were not well cleaned. Here, again, the percentage was above the average. In several collieries where the average was high, the lamps were cleaned by hand, a very inefficient proceeding compared with the machine cleaning.

Table XVI.—Oil used in 43 Collieries.

	No. of pits.	Percentage of nystagmus.
High grade paraffin.....	16 (14 entirely)	0·58
Mixture of colza and paraffin	4 (3 ")	0·68
Spirit or naphtha	6 (5 ")	0·71
Mineral colza	15 (14 ")	0·81
Colza	9 (8 ")	0·93

Lamps compared with the standard candle (Report of Mines Accident Commission, 24):—

Davy	0·19
Clanny.....	0·62
Mueseler.....	0·69
Marsaut	0·68

We do not realise how much of our light is due to diffused reflecting power of the walls of any building we happen to be in. In the coal mine practically all the light is absorbed.

Ocular Defects.

This introduces the personal factor of the disease, and one which has been too much neglected in the past. It has always struck me as strange that when two men are working together under similar circumstances one may be affected and the other left. I have examined men who have been underground for 60 years without showing any sign of nystagmus. Yet a case may develop after six months' underground life (Case 19).

The disease has been shown to attack the men who use their eyes the most in a much larger proportion than the other men.

My figures are incomplete, but they show that a large proportion of men suffer from error of refraction. T. Thompson (20) brings out this point, but his cases are few. Romiée also says (2) that a large proportion are hypermetropics, but in his later communications does not lay much stress on this point. Dransart (5) and Snell (17) say that the majority of cases are normal.

I have tested my cases for visual acuity and error of refraction; it was impossible to examine all, from lack of opportunity or time. As it was important not to call the attention of the latent cases to the fact that they had nystagmus these were not examined.

Table XVII.—Visual Acuity.

Too bad to test	18
Not examined	39
Normal	43
6/9	53
6/12.....	46
6/18.....	67
6/24.....	52
6/36.....	43
6/60.....	39

The fraction gives the proportion of power of vision to normal; thus 6/12 = half normal, etc.

Table XVIII.—Showing Error of Refraction.

Not examined	46
Latent.....	43
Too bad to test	31
	—
	120
Apparently normal	18 (6·4 per cent.)
Error	262 (93·6 per cent.)

Table XIX.—Showing Kind of Error.

Hypermetropia (long sight).....	105
Myopia (short sight).....	37
Astigmatism—	
Hypermetropic	91
Myopic.....	26
Mixed	3

Table XX.—Showing Degree of Error.

Less than 1 Diopter	102 (chiefly astigmatic)
1 to 2 D	110
2 to 3	30
3 to 4	9
4 and over	11

All have weakness of accommodation. They are unable to fix a point for any length of time, and they turn away their heads or cover their eyes with their hands after a short time.

Many cases show internal squint, and injection of the eyes is frequent.

Observations on Pigmentation.

Early in my investigation I noticed that several of my severe cases had blue eyes and fair hair. The possibility of a partial albinism suggested itself, and I took notes of all cases. Nettleship (25), in his Bowman lecture and elsewhere (26), suggests that congenital nystagmus may be due to a partial albinism confined to the eyes.

Table XXI.—Showing Colour of Hair and Eyes in Nystagmic Cases. With each colour eye three sets of figures are given; the first refers to fair-, the second to medium-, and the third to dark-haired people.

Blue	62, 61, 47, eyes only noted, 15, total 185	} 258, or 64·5 per cent.
Blue-grey and grey..	15, 25, 32 „ 1, „ 73	
Light brown	6, 13, 17 „ „ „ 36	} 142, or 35·5 per cent.
Dark brown	3, 43, 53, eyes only noted, 7, total 106	

Table XXII.—Control Test, Adult Miners, same District.

Blue	59, 76, 57, total 192	} 272, or 41·97 per cent.
Blue-grey and grey	13, 17, 50, „ 80	
Light brown	5, 70, 43, „ 118	} 376, or 58·03 „
Dark brown	5, 53, 200, „ 258	

Table XXIII.—Colour of Hair.

	Nystagmus.	Control.
Fair.....	86	82
Medium	142	216
Dark	149	350
	} 228 } 298	

Relation of Nystagmus to Accident.

In 76 cases there was a distinct connection between the onset of the disease and an accident. The accident was to the head in 33 cases, to the eyes in 28, and to the body in 15. I have no space at present to quote cases. I am also convinced that nystagmus predisposes to accident, but the subject is such a difficult one that I am unable at present to give any figures.

Diagnosis of Nystagmus.

The patient should be asked to fix the finger tip held about 12 inches in front of and on a level with the eyes. If movement does not appear, gradually elevate the finger, asking the patient to follow. Note the degree above the horizontal at which movement begins; this gives a rough test of the severity of the disease (Romiée (1)).

If this fails ask the patient to stoop or exert himself. The eyes may be examined in a mirror held under the patient's head while he remains in a

stooping position. A pencil of light may be focussed at the junction of the cornea and sclerotic in a dark room.

The rotation test advised by Reid (19) should not be used, as normal people give the test. I have found the ophthalmoscope of no assistance. Several examinations may be necessary.

A test which is valuable, although not absolutely conclusive, is the following "head test." If the patient is asked to look up while the head is kept strongly flexed by the observer's hand a head tremor may often be felt in cases where the movement of the eyes is absent. This test is frequently given by long-standing cases in which movement has disappeared.

When movement occurs the character must be noted, as true miners' nystagmus gives a rotatory movement. If the movement is purely lateral and is not equal on both sides grave suspicions should be aroused. The case may be one belonging to the group of nervous diseases, such as disseminated sclerosis, syringomyelia, or cerebellar tumour, which give the symptom of nystagmus.

It is also necessary to exclude cases of high myopia, of which I have seen two examples, and the congenital conditions, such as hereditary nystagmus or albinism, of which I have seen several examples. Lastly, some people can produce nystagmus voluntarily (27, 28). I have seen one case.

Prognosis.

Slight cases recover quickly and completely; severe cases slowly and often incompletely. Table VI, containing so many bad cases, is not so just as the following, taken from the three large colliery companies for a period of four years:—

Back at old work.....	57
Left employ = recovery	5
Surface work (including six who failed underground)	68
Still idle.....	30

The prognosis in individual cases depends on the age, length of symptoms before failure, degree of elevation necessary to produce movement, visual acuity, presence of error of refraction and the presence or absence of tremor of the head.

Causes of Nystagmus.

I regard the disease as one of extreme complexity and one in which many factors are at work. The chief factor is strain caused by deficient light. Error of refraction, deficiency of retinal pigment, position assumed at work, accident and ill-health are all factors of less importance.

As the result of working for long periods in the comparative darkness of the pit, the cells of the retina probably lose their power of producing sufficient pigment for exact vision. This failure occurs sooner in fair blue-eyed people and in people who, owing to refractive error, are subject to a greater eye-strain. The more frequent occurrence of nystagmus in winter, the loss of visual acuity, the dread of light, are all points in favour of this theory. Another is the oblique position in which the head is held in many cases. This is probably due to an attempt made by the patient to bring a fresh part of the retina into play, the central portion being worn out: "In the dark and with an absolutely homogenous field before them the eyes are always moving" (Maddox, 29). These conditions nearly obtain in a coal mine.

This diminished power of fixation calls for efforts by the higher centres for better vision. Excessive accommodation and resulting eye-strain follows. Darkness itself is not enough to set up nystagmus.

Horses do not show any signs of the disease even after 10 years' continual underground life. I examined 46 horses without result.

Lower animals have no central fixation (Maddox) and the horse has apparently two fields of vision and consequently no need for associated vision. They are also free from eye-strain.

The position assumed by the miner, especially when the head is flexed and the eyes look up (Jeaffreson), also has some influence.

The total result is that the impulses passing to the brain are not so exact as they should be and that the centres governing the associated movements of the eyes are correspondingly disturbed. The intimate connection between these centres is lost and incoördinate movements of the eyeballs result.

Snell, Dransart, and others lay great stress on the fact that nystagmus is best seen and often only brought out when the eyes are elevated, and they attribute this to weakness of the elevator muscles. It is not the muscles which are affected but the movements of elevation.

This failure is most marked in elevation of the eyes for two reasons:— (1) The movements of elevation are the weakest and least often used of all the associated movements of the eyes; when the centres are put to a severe strain they are the first to go. (2) If the movements of the eyes are noticed in the vertical plane it will be seen that in all positions below the horizontal there is an associated convergence, while in all positions above there is a tendency to divergence. The eyes are in a position of maximum stability when depressed and converged, and consequently nystagmus is not found in this position except in severe cases.

In many cases, and in most long-standing cases, the head is thrown back, the eyelid droops, and the patient looks out at you from half-closed eyes. He

assumes this position, in my opinion, to bring his eyes into a relative position of depression and convergence (the position of maximum stability), and at the same time to direct his plane of regard horizontally forward.

The character of the movements, the sudden onset in many cases (50), the influence of accident, and the character of the tests used to bring out the movements, all point to incoördination as the starting point of the disease.

Preventive Measures.

The results of this investigation show clearly that the most important preventive measure is improvement in the lighting power of the miner's lamp. If oil lamps are used, careful attention should be given to the cleaning of the lamps and quality of oil. If possible, a lamp giving a diffused light should be introduced. Shades should always be fitted to the lamps to be used in going to and from the face. (This is now in force in the Powell Duffryn pits of the Rhymney Valley.)

No man with error of refraction should be allowed to work underground. Simple tests should be put to all fresh men by the managers, and if the result is not satisfactory, the man should not be employed without a medical examination. I believe that if this precaution were taken, half the cases of nystagmus could be avoided. The introduction of coal-cutting machines in thin seams is also of assistance.

Table XXIV.—Use of Coal Cutters (43 Collieries).

	Collieries.	Percentage of nystagmus.
Extensively	6	0·49
Partly	15	0·73
Not used	22	0·81

Improvement of ventilation, which also means a better light, is also of the greatest importance, since the light given by a lamp falls off very rapidly as the oxygen percentage of the air diminishes.

I am now engaged in the measurement of illumination at the working places, in experiments on the effects of introducing electric lamps, and in the collection of further evidence as to the causation of the disease, with a view to a further and much more full report.

In presenting this preliminary report, I wish to acknowledge the very great and willing help I have received from both the mining and the medical

fraternities. To Dr. Haldane, especially, I am indebted for much valuable help and encouragement.

The Directors of the Powell Duffryn Company and Rhymney Iron Company, the South Wales Colliery Owners, and the South and West Yorkshire Colliery Owners, have given me every facility.

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On the Effects of Castration and Ovariectomy upon Sheep.

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It is well known that castration, when performed in early life and before sexual maturity has been reached, has a marked effect not only in inhibiting the development of the accessory male organs, but in changing the general conformation of the body. Thus in castrated guinea-pigs, oxen, and capons, as well as in eunuchs, the bones of the limbs tend to be abnormally long, this result depending upon an arrest in the ossification of epiphyses. The secondary male characters are also in many cases suppressed, so that there is an apparent approximation to the female type. Thus in red deer if the testes are removed in quite immature animals the antlers fail to make their appearance, and in fallow deer castration at birth limits the horn formation to the development of single dugs. Secondary sexual characters, however, are not always correlated with the presence of the essential reproductive organs, even in mammals. Thus the withers in the gelding resemble those of the horse rather than those of the mare, in which the withers are lower. Moreover, in certain varieties of cattle in Italy, the horns in the ox, if castration has been carried out young, are far longer than those of either the bull or the cow.

Ovariectomy in the female is often said to lead to the assumption of male characters, but there is little experimental evidence that this is actually the case. In the human female complete removal of the ovaries, if carried out in early life, besides preventing the onset of puberty and the occurrence of menstruation, produces effects on the general form and appearance, individuals so operated upon being said, in some cases, to show resemblances