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**JOINT LAXITY AND OSTEOARTHRISIS:
A RADIOLOGICAL SURVEY OF FEMALE PHYSICAL EDUCATION SPECIALISTS**

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ABSTRACT

Three hundred and sixty-four female specialist teachers of physical education who qualified between 1935 and 1950 agreed to have x-rays of the lumbar spine, hips and knees. Fifty-two had osteoarthritis of the hip, 65 osteoarthritis of the knee and 221 degenerative change in the spine. Overall osteoarthritis of the knee was significantly less common than in a comparable sample from the general population ($p < 0.001$), severe or moderate osteoarthritis being equally common in both groups but minor or minimal osteoarthritis being much less common in the teachers. There was no significant difference in the prevalence of osteoarthritis of the hip between the two populations though severe osteoarthritis of the hip was slightly more common in the teachers.

A postal questionnaire, attempting to determine factors that might have contributed to the pathogenesis of osteoarthritis was sent out and 291 (80%) replied.

Radiological changes were not related to height but there was a slight association with increased weight. Family history was often contributory and nine subjects had had a meniscectomy which probably contributed to osteoarthritis of the knee.

Joint laxity may produce osteoarthritis and subjects scored their own laxity status with two simple scoring systems. Overall joint laxity did not correlate with degenerative change in the spine. There was a slight association of laxity with OA of the hip and knee but this did not reach significant levels.

Regular physical exercise may protect from osteoarthritis in lax joints by producing stability through increased muscular tone.

Key Words: Osteoarthritis, Joint Laxity, Physical Education

INTRODUCTION

The precise aetiology of osteoarthritis remains obscure though what was once thought to be a single disease is now recognised to be a collection of disorders, probably all with different aetiological factors (Ball and Sharp, 1978). It is likely that many examples of "primary" osteoarthritis would be classified as "secondary" with greater insight into their aetiology.

One previously suspected cause was repeated trauma to the joint or "repetitive impulse loading" though recent studies of groups who might therefore be suspected to be at risk such as free fall parachutists (Murray-Leslie et al, 1977) and pneumatic road drillers (Burke et al, 1977) failed to show an increased prevalence of radiological osteoarthritis when compared to age matched controls. Sports enthusiasts might also be at risk but Adams (1976) failed to demonstrate excessive osteoarthritis in professional footballers and a recent radiological survey of female specialist teachers of physical education, aged 45-60, from this Unit, failed to show an increased prevalence of osteoarthritis of the hip or knee (Eastmond et al, 1980).

The severe joint laxity seen in certain hereditary disorders of connective tissue such as the Ehlers-Danlos syndrome is known to produce premature osteoarthritis of a degree proportional to the severity of the laxity (Beighton and Horan, 1969). Recently benign familial generalised joint laxity has been shown to produce both premature osteoarthritis (Kirk et al, 1963; Bird et al, 1978) and crystal deposition disease (Bird et al, 1978) and this variant of laxity is more likely to occur in sportspeople. Indeed joint hyperlaxity may preselect individuals for activities such as ballet (Grahame and Jenkins, 1972), hurdling and gymnastics (Bird, 1979) and the only severe example of osteoarthritis in Adams' series of footballers was one with unusual joint laxity at the knees, presumed due to trauma.

Joint laxity in students of physical education, aged 18-21 has recently been studied (Bird et al, 1979). Although no significant difference in laxity emerged compared with age matched non-physical education students, a few individuals, perhaps selected because of expertise in certain sports, demonstrated marked laxity. In a comparison of scoring systems for the quantification of laxity, that devised by Carter and Wilkinson (1964), modified by Beighton (1973), performed best and was simple. Laxity is scored according to the subjects ability to perform a series of simple manoeuvres that can be demonstrated in diagram form.

In order to determine the prevalence of osteoarthritis in the knees, hips and lumbar spine of female specialist teachers of physical education, radiographs of these joints had previously been collected from 364 specialist teachers (Eastmond et al, 1980). It was decided to send

a postal questionnaire to these participants asking them to assess their joint laxity by means of diagrams on a "do-it-yourself" basis both at present and, from memory, before and after their specialist training. This would determine whether there was a relation between patterns of joint laxity and those individuals in whom osteoarthritis had occurred. Information was also sought on other factors known to precipitate premature osteoarthritis.

SUBJECTS AND METHODS

Three hundred and sixty-four women, all of whom had trained as specialist teachers of physical education between the years 1935 and 1950, were contacted through the registers of their six colleges of physical education. All of these had previously attended their local hospital for a lateral x-ray of the lumbar spine and A.P. x-rays of the pelvis to show the hips and knees. The x-rays were taken in 1975, the women having been contacted by a postal questionnaire. The age of the teachers at x-ray was 46-60 years. Radiographs were then read blind by two rheumatologists in consultation (C.E. and V.W.), the grading performed by comparison with the Atlas of Standard Radiographs. Osteoarthritis of both hip and knee was graded for each of the four joints on a 0-4 basis. In the spine degenerative change was also graded 0-4 at each of six sites; D12/L1, L1/L2, L2/L3, L3/L4, L4/L5 and L5/S1. An index of degenerative change for the spine was calculated by adding the scores at each site, the maximum score possible being 24.

In order to determine possible factors that might have contributed to the pathogenesis of osteoarthritis, where this was seen, a second postal questionnaire was sent to all 364 women in 1978. This determined the following:

- (a) present weight and height and whether these had altered since student days.
- (b) Family or personal history of arthritis of any sort.
- (c) Details of injuries and fractures that might have contributed to osteoarthritis.
- (d) Presence of known associations of joint laxity such as flat feet, varicose veins, hernia, delayed skin healing and easy bruising.
- (e) Whether there was any family history of joint laxity.
- (f) The number of hours spent each week in active physical exercise
 - (1) on leaving college
 - (2) 10 years later
 - (3) at present (1978)
- (g) The state of joint laxity, assessed by the subject in two ways:
 - (1) Carter and Wilkinson Score (1964) modified by Beighton (1973) measured with the aid of a series of diagrams on starting P.E.

college, on leaving P.E. college and at present. One point is allocated for the ability to perform each of the following manoeuvres:

- (i) Passive dorsiflexion of the little fingers beyond 90° (one point for each hand) 2 points
- (ii) Passive apposition of the thumbs to the flexor aspects of the forearm (one point for each thumb) 2 points
- (iii) Hyperextension of the elbows beyond 10° (one point for each elbow) 2 points
- (iv) Hyperextension of the knees beyond 10° (one point for each knee) 2 points
- (v) Forward flexion of the trunk with knees extended so that the palms of the hands rested on the floor 1 point

TOTAL 9 points

Subjects were requested not to guess and to leave blanks if they were uncertain.

- (2) Subjects stated whether, as a student, compared with the others in their group they considered themselves very stiff/stiff/normal/supple/very supple. It was felt this subjective assessment was valid since the group studied were intelligent subjects with training in anatomy and physiology.

Subsequent analysis was performed by a third rheumatologist (H.B.) who had not been involved in the interpretation of the x-rays using chi-square test or students t test, as appropriate.

A control group was obtained by comparing these x-rays with the published findings on the prevalence of osteoarthritis of the knee and hip in the Leigh and Wensleydale surveys of normal females of comparable age (Lawrence, 1977). It was felt no suitable comparable data was available on the lumbar spine in a normal population.

RESULTS

Osteoarthritis of the hip was seen in 52/364 x-rays. It was bilateral in 13 subjects and unilateral in 39. Osteoarthritis of the knee was seen in 65/364 x-rays. It was bilateral in 27 subjects and unilateral in 38. Only 8/364 had osteoarthritis at both hip and knee. Degenerative changes of the spine were considered to be present in 221/364 individuals.

When osteoarthritis of the knees in physical education teachers (age 46-54 years) was compared with knees of a normal population (age 45-54 years), there was significantly less osteoarthritis in the teachers

(chi squared = 28.12 (4 DF); $p < 0.001$). The prevalence of grades 3 and 4 knee osteoarthritis was similar in both groups, whereas teachers had a much lower prevalence of minimal and minor degrees of osteoarthritis (grades 1 and 2). Exact comparison of an older age group was impossible because of disparity between the ages of the two populations. However, it is probable that the teachers did not have significantly more osteoarthritis than controls.

Although there was a slightly increased prevalence of grade 2-4 osteoarthritis of the hips in the teachers, aged 46-54, and also in the older group, in neither case did this reach statistical significance compared to the control population.

291/364 individuals (80%) replied to the questionnaire. Two subjects had died and six questionnaires were returned to us unopened because of change of address. Analysis was subsequently confined to these 291 individuals, 32 of whom had osteoarthritis of the hip, 45 osteoarthritis of the knee and 6 osteoarthritis at both sites.

Weight and height of the subjects who replied to the questionnaire, arranged by radiological diagnosis are shown in Table I. There was no significant difference in weight or height between any two groups though patients with osteoarthritis of knee or hip tended to be heavier, although of the same height, as subjects without osteoarthritis.

A family history of osteoarthritis is hard to validate on a postal questionnaire. However, on the clinical description given by respondents of the joint problems involving their parents it is likely that there was a family history of osteoarthritis in at least 6/32 subjects with OA hip, 10/45 subjects with OA knee and 3/6 subjects with osteoarthritis at both sites. There was a history either of joint surgery or fracture, reported to involve a joint cavity in 15/83 subjects with OA of the hip or knee or both. Operations that might have been performed because of osteoarthritis, e.g. hip replacement and osteotomy, were excluded. A striking feature was that nine of these fifteen subjects, all with radiological osteoarthritis of the knee had had a "cartilage operation" on the involved joint during their sporting career. Factors that might have predisposed to osteoarthritis in the other six subjects were fracture of the femoral head or neck (2), spinal fusion (1), laminectomy (1), fractured lumbar vertebrae (1) and fractured patella (1).

Our study design relied heavily on the memory of subjects completing the questionnaire. As a check on the reliability of this we investigated the relation between the recorded joint laxity scores and the presence in the family of "double-jointed" relatives. Familial joint laxity is usually inherited and first degree relatives

Fig. 1. Grade 2 osteoarthritis in both knees.

Fig. 2. Grade 4 osteoarthritis in the left knee; normal right knee.

Fig. 3. Grade 1 osteoarthritis in both hips.

Fig. 4. Grade 2 osteoarthritis in both hips.

Fig. 5. Grade 4 osteoarthritis of the left hip; grade 3 osteoarthritis of the right hip.

Fig. 6. Bilateral grade 5 osteoarthritis, an exceptional finding in this study. The patient has bilateral hip arthroplasties.

Fig. 7. Osteoarthritis of the spine graded as a total score of 13 (3/3/1/0/3/3).

TABLE I

Weight and height in 291 subjects replying to the questionnaire, grouped by radiological diagnosis

	Mean Weight and range kg.	Mean Height and range cms.
32 subjects with OA hip	62.2 (45.8-72.6)	164 (155-179)
45 subjects with OA knee	66.0 (50.8-114.3)	166 (158-180)
6 subjects with OA hip and OA knee	64.3 (57.1-66.7)	165 (160-170)
208 with no radiological change at hip or knee	61.6 (45.8-95.3)	165 (156-179)

are often involved (Bird, 1980). 33/291 respondents thought they were "double-jointed" themselves (18) or had "double-jointed" relatives (13) or both (2). Table II shows chi-square analysis of the differences between "double-jointed" families and the others using the different scoring systems employed. Carter and Wilkinson score on starting P.E. college is omitted since this only occasionally differed from the score on leaving college. When a difference occurred it was usually of only one point; over three years of training individuals who could not previously place their hands flat on the floor in

front of them tended to acquire this skill. Differences between the two groups were highly significant for all the scoring systems used. Considering "double-jointed" relatives who were reliably documented (daughter 9/son 5; brother 2/sister 1; mother 1/father 1; other females 1/other males 2) it was of interest to note that the sex ratio male/female was almost equal, 10/12 respectively, perhaps confirming an autosomal rather than sex linked inheritance of generalised joint laxity that has previously been suggested (Beighton and Horan, 1970). There was a high prevalence of known systemic associations of joint laxity such as "flat feet" and varicose veins in those individuals with high Carter and Wilkinson laxity scores, reflecting the recognised disseminated nature of the connective tissue disorder.

Although comprehensive information was provided by respondents on the hours they spent on sporting activity on leaving college, ten years after leaving college and at present, the sports played and degree of achievement were so diverse that it was felt impossible to investigate the role of repetitive impulse loading on the pathogenesis of osteoarthritis further from a survey of this sort.

The distribution of joint laxity throughout this population according to the scoring systems tested is shown in Table III. The subjective scoring system gave an almost gaussian distribution of laxity and the pro-

Fig. 8. Osteoarthritis of the spine graded as a total score of 8 (0/0/0/2/2/4).

TABLE II
Validation of scoring systems by comparison of
"double-jointed" families with "normal" families

(a) Subjective Assessment

	33 from "double-jointed" families	258 others
Very supple	4	11
Supple	14	41
Normal	13	167
Stiff	2	30
Very stiff	0	9
$\chi^2 = 19.39$	DF = 4	p < 0.001 H.S.

(b) Carter and Wilkinson Assessment

	ON LEAVING COLLEGE		PRESENT	
	22 respondents from "double-jointed" families who remembered their score	182 others who remembered their score	32 respondents from "double-jointed" families	252 others
Score				
9/8/7/5	4	2	2	0
5/4	5	13	8	9
3	6	25	2	17
2	3	7	5	17
1	4	93	4	78
0	0	42	11	131
	$\chi^2 = 39.95$		$\chi^2 = 46.52$	
	D.F. = 5		D.F. = 5	
	p < 0.001 H.S.		p < 0.001 H.S.	

TABLE III
Distribution of joint laxity in the population studied

(a) Subjective Score

Very Supple	15 (5.2%)
Supple	55 (18.9%)
Normal	180 (61.9%)
Stiff	32 (11.0%)
Very Stiff	9 (3.1%)

TOTAL align="center">291

(b) Carter and Wilkinson Score

Score	0	1	2	3	4	5	6	7	8	9	Total
On starting P.E. college	52 (25.7%)	87 (43.1%)	10 (4.9%)	30 (14.8%)	2 (1.0%)	15 (7.4%)	1 (0.5%)	2 (1.0%)	—	3 (1.5%)	202
On leaving P.E. college	42 (20.6%)	97 (47.6%)	10 (4.9%)	31 (15.2%)	2 (1.0%)	16 (7.8%)	—	3 (1.5%)	—	3 (1.5%)	204
At present	142 (50.0%)	82 (28.9%)	22 (7.8%)	19 (6.7%)	5 (1.8%)	12 (4.2%)	—	1 (0.3%)	1 (0.3%)	—	284

gressive Carter and Wilkinson scores showed a reduction in joint laxity with age. Table IV shows the distribution of joint laxity in subjects with radiological osteoarthritis of the hip compared with the rest of the population and Table V shows the same analysis for subjects with radiological osteoarthritis of the knees. No significant increase or decrease in laxity was seen for either pathology though there was a slight trend for those subjectively graded as "supple" as a student to have osteoarthritis of the knee and for those graded high on the Carter and Wilkinson score as a student to have osteoarthritis of the hip. Table VI shows the laxity distribution in subjects with degenerative change of the spine of varying severity. No significant association was seen.

TABLE IV

Joint laxity in osteoarthritis of the hip

(a) Subjective

	38 respondents with OA hip	253 respondents without OA hip
Very supple	2	13
Supple	6	49
Normal	25	155
Stiff	2	30
Very stiff	3	6

N.S.

(b) Carter and Wilkinson

Score	ON LEAVING COLLEGE		PRESENT	
	28 with	176 without	38 with	246 without
9/8/7/6	1	5	0	2
5/4	5	13	4	13
3	2	29	3	16
2	0	10	2	20
1	11	86	10	72
0	9	33	9	123

N.S.

N.S.

TABLE V

Joint laxity in osteoarthritis of the knee

(a) Subjective

	51 respondents with OA knee	240 respondents without OA knee
Very supple	4	11
Supple	8	47
Normal	34	146
Stiff	5	27
Very stiff	0	9

N.S.

(b) Carter and Wilkinson

Score	ON LEAVING COLLEGE		PRESENT	
	33 with	171 without	49 with	235 without
9/8/7/6	0	6	0	2
5/4	3	15	2	15
3	8	23	4	15
2	3	7	3	19
1	13	84	15	67
0	6	36	25	117

N.S.

N.S.

TABLE VI

Joint laxity in degenerative change in the spine

(a) Subjective

	Radiological Score					
	11 to 15	4	3	2	1	0
Very supple	3	2	1	0	0	9
Supple	5	11	5	7	5	22
Normal	22	16	23	22	21	76
Stiff	4	5	4	4	3	12
Very stiff	1	0	0	2	2	4
No. of respondents	35	34	33	35	31	123

N.S.

(b) Carter and Wilkinson

Score	ON LEAVING COLLEGE		PRESENT	
	23 with radiological score 11-5	181 with lower score	35 with radiological score 11-5	284 with lower score
9/8/7/6	0	6	0	2
5/4	1	17	2	15
3	2	29	1	18
2	3	7	7	15
1	10	87	9	73
0	7	35	14	28

N.S.

N.S.

Subsequent analysis of the proportion of subjects in each laxity group as a student who might expect to develop osteoarthritis at various sites in old age, showed a slight trend for those who were "supple" to have an increased risk of osteoarthritis of the hip or knee but not of the spine. Susceptibility to degeneration of the spine was spread evenly throughout all laxity groups.

There was little clustering of osteoarthritis at

different sites. Thus of 52 subjects with radiological osteoarthritis of the hip, 31 subjects had degeneration of the spine though only eight had knee involvement. Of 65 subjects with radiological osteoarthritis of the knee, 44 had degenerative change in the spine. Since 221/364 lumbar spine x-rays showed degenerative change we found no significant evidence that change at one site was linked with change at another.

DISCUSSION

The results of the radiological survey do not show an increased prevalence of osteoarthritis of the hips and knees in this group of female physical education teachers. The presence of osteoarthritis of the hips is similar to that in the general population whilst the more severe grades of osteoarthritis of the knees are equally prevalent in the teachers and the general population. There appears to be less mild and moderate osteoarthritis in the teachers compared with the general population, throughout the whole age spectrum. However, although the athletic population was not at particular risk, it was felt further study within this selected intelligent group might provide clues to the pathogenesis of osteoarthritis in the few individuals in which it occurred.

Comparative analysis between patients with and without osteoarthritis in the same group, even though this group is highly selected compared with a normal population, is a valid method of analysis, especially since there are anecdotal grounds for suspecting some subjects may be at risk. The precise study design requires more justification. Although we have relied on the memory of our subjects, stretching back over 45 years in some cases, we felt this was justified in these particular specialists who had received training in sport, anatomy and physiology and were all of above average intelligence. We felt they could be relied upon not to guess. The group acts as its own control and although our respondents have not been stratified by age this seemed reasonable providing we were making comparisons within the group rather than adjudicating on prevalence rates. The scoring systems used reflect "global laxity". It is possible that in the case of the spine, an assessment of laxity of the vertebral column would have been more relevant than the scoring systems we used though this would have been difficult in a postal survey.

It may be fallacious to consider "global osteoarthritis". Ball and Sharp (1978) have drawn attention to the many pathologies that may lead to osteoarthritis at distinct sites. Assuming these predisposing factors to lead to the same common pathway of degenerative change, probably biochemical, Kempson et al (1973) have pointed out that the collagen content of the same zone analysed from 20 femoral cartilages from different individuals varied from <45% to 90% of the dry weight. Superimposed on the individuals anatomical variation

is the effect of mechanical stresses. Seedhom (1979) has drawn attention to the wide variety of stresses that can be initiated in the patellofemoral compartment of the knee joint leading to premature osteoarthritis at distinct sites according to the stresses measured. This is particularly relevant in a group selected because of their participation in a wide variety of sports.

Although there were a few trends apparent, we found no evidence reaching statistical significance that a subgroup of our population developed osteoarthritis because of joint laxity, either inherited or acquired. We feel the inherent weaknesses in a postal survey preclude an answer to the hypothesis that laxity localised to certain joints may lead to localised osteoarthritis in certain individuals. Nevertheless we have found no evidence that those who displayed high laxity scores were predisposed to widespread osteoarthritis. This conclusion is at variance with the survey of Scott et al (1979) who showed a statistically significant association between joint laxity measured on the Carter and Wilkinson system and symptomatic osteoarthritis in a randomly selected hospital population admitted for non-rheumatological indications. It also contradicts the impression that in a group of patients referred to a rheumatology clinic generalised joint laxity invariably leads to premature osteoarthritis (Bird et al, 1978). One reason is that this group were highly selected because of hospital attendance and it may be of more significance that none of the patients studied were athletes. It is an attractive hypothesis that even if a joint displays laxity, regular athletic training, by increasing muscle tone will stabilise the joint thereby preventing or even protecting from osteoarthritis. Joint instability may be more potent than joint laxity in the pathogenesis both of human osteoarthritis and of experimentally produced canine osteoarthritis where joint incongruity is achieved by dividing the anterior cruciate ligament of the dog knee joint (Pond and Nuki, 1973).

The link between meniscectomy and osteoarthritis of the knee is of interest. It has been described previously by several groups (Wynn Parry et al, 1978; Tapper and Hoover, 1969; Johnson et al, 1974). It demonstrates a problem of studying a selected group; sporting activity may lead to damage of the menisci requiring operative intervention which in turn predisposes to osteoarthritis. The relative lack of clustering of affected joints in this series was also striking. It is well recognised in clinical rheumatology that osteoarthritis of one hip or knee joint is associated with "secondary" osteoarthritis of the contra-lateral knee or hip joint respectively; a finding attributed to mechanical factors. Whilst no prevalence figures are available for this association it is our impression that osteoarthritis of both knee and hip joints, seen in only 8/117 examples of lower limb osteoarthritis, may be less frequent in physical education specialists than in others. One explanation is that the secondary

osteoarthrosis of the second joint may be of slow onset and was not therefore seen in this relatively young population; an alternative is that regular sport may have a sparing effect in the development of secondary mechanical changes.

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BOOK REVIEW

Title: **SPORT PSYCHOLOGY: An Analysis of Athlete Behaviour**
Editor: William F. Straub
Publisher: Mouvement Publications, Ithaca, New York
Price: \$9.95 £2.95 Paperback

As the Editor states in his Preface to this selection of American, Canadian and British readings: "The mind is sport science's last frontier. All other systems have been extensively used to improve athletic performances." Although interest in the psychology of sport has been around for as long as sport itself, it is only the past 10 or so years that the science of behaviour has begun to be applied systematically. The expressed intention of this book, according to Straub, is to "help coaches and students of sport behaviour become more aware of the techniques available to change athlete behaviours."

The emphasis is placed deliberately on topics usually studied in undergraduate and graduate physical education courses, and Straub's idea was for the readings to be used in conjunction with a standard text (though he does not specify which ones he had in mind). Half the contributions — there are 32 in all — were commissioned and the others chosen for inclusion as "classics" in their field. Straub wanted very much to help the "coach on the job" with factors affecting an individual's performance and team success, and the contents reflect this.

The text is divided into 11 sections: Introduction (which includes a general overview of the subject, and deals with the following aspects: developmental, personality and clinical, learning and training, social and psychometrics; this is followed by a run-down of behavioural principles and applications; and an account of the USA's first sport psychologist who was active over 50 years ago); Motivation of Athlete and Team; Aggression; Humanism and Performance; Attention and Anxiety; Meditation and Performance; Social and Cultural Aspects; Psychological Health; Personality; Leadership Style; and Team Cohesion. There is no index.

This wide-ranging compilation provides a happy marriage of contributions by clinically-orientated psychologists and those with a physical education background, of which the following are of particular interest: Suinn on behavioural assessment and modification, especially his cognitive approaches; Halliwell on intrinsic motivation; Nideffer on attention and anxiety; Loyman on the role of meditation in sports performance; Burke and Kleiber on psychological pressures of competitive sports on children; and that seldom dealt with topic — psychological problems encountered at the end of an athletic career, by Jack Cratty.

Theories abound over the 295 pages but not many hypotheses are put to the test. However, the book's heuristic value should compensate for that; it provides a rich supply of source references, and is definitely one of the most comprehensive and accessible texts on the still young field of sport psychology. It is essential reading for anyone interested in the person behind the performance. Perhaps we can look forward, in due course, to a second edition with more data to back up the theorising.

Maurice Yaffé