

SOME RESULTS OF AN EXPERIMENTAL
INVESTIGATION INTO THE MORPHO-
PHYSIOLOGY OF JOINTS

BY

D. E. HOLMDAHL

In planning the experimental investigation into the morpho-physiology of joints which I shall describe here, and which has been carried out by Prosektor *Ingelmark* and myself, we had to consider two main aspects, the practical medical and the theoretical medical aspects.

The practical medical observations were made at Sättra Brunn, where many hundreds of joint disorders of various kinds and degree are treated every year. Here a systematic physical treatment is carried out as the basic method of treatment. This work has shown very encouraging results which we recently reported in *Acta Medica Scandinavica*.

How then can one explain these results? It is here that the recent investigation into joint morphophysiology can be of help concerning the relation between structure and function. In it we are considering the other, the theoretical medical aspect.

Here we are concerned with the question of functional structure on the one hand and functional adaptation on the other. It should be obvious that the cartilage of a joint has a very suitable shape and structure, which, by the arrangement of its constituents and bulk, give the best function possible, with the least substance. The question remains whether this

structure can be altered with function. Many have assumed that such an adaptation does occur, but it has not so far been proved. If it is possible to demonstrate it, then the favourable effect of physical therapy on joint disorders becomes theoretically justified and intelligible.

This investigation is based on extensive experiments on animals. 60 rabbits were used; some of them were systematically exercised during their growing period, and the others were kept at rest. All the joints were examined in the two groups. The many observations have been studied in detail and analysed statistically.

The main results of the investigation are the following: First, concerning the thickness of the joint cartilage, that is to say, of the uncalcified cartilage:

1. The cartilage is thickest in the central, most functioning parts of a joint.
2. The ball of a joint has thicker cartilage than the socket.
3. The bigger the joint, the thicker is the cartilage.

These facts alone point to a positive correlation between the thickness of cartilage and its function. This was still clearer when we were able to establish that the exercised animals had thicker cartilage than the unexercised, and that the increase in the exercised compared with that in the unexercised animals was both absolutely and relatively greater in the joints which have thicker cartilage than in those which have thinner. In other words the parts which have the greatest function respond with the greatest increase in thickness.

Concerning the content of cellular tissue in the joint cartilage it was found that:

1. The percentage content of cellular substance is greater in the cartilage of the ball than in that of the socket.
2. The cartilage of the bigger joints has a lower cell content than that of the smaller joints.
3. Exercise produces an absolute increase in the content of both cellular and intercellular substance, but the increase of the intercellular substance is 4 times that of the cellular. This observation should be of special interest for the assess-

ment of the functional adaptation of the cartilage of a joint.

There is also a difference between the two groups in the number of cells per chondron and in the size of the cells. This observation, which is highly interesting from the theoretical standpoint, I must pass over for lack of time.

Thus the investigation has shown that the structure of hyaline joint cartilage changes with function during growth and that one must therefore recognise that functional modification occurs, at least during growth.

This had not been definitely demonstrated previously. Statements to the contrary in the literature must be considered to be incorrect.

The fact that such a functional adaptation really occurs, as is now shown, is of great both theoretical and practical interest.

Thus the following questions concerning cartilage arise. How can one imagine that the firm, elastic, apparently stable and unchanging cartilage tissue can change in the way such a functional adaptation presupposes. Here one comes to the central biological questions concerning, e.g. the manner in which the intercellular substance is formed, the possibility of regeneration of joint cartilage, etc. Here it is a question of the formation of the collagenous fibres of the joint cartilage, and of the matrix, which is made up of chondroitin sulphuric acid. I have not time to discuss this here, except to mention that recent tissue culture experiments make it possible to understand that variability of shape, as determined by function, may persist in joint cartilage as well as in other tissues.

From the practical medical standpoint the confirmation of a functional adaptation of joint cartilage must have lasting consequences. If the structure of the cartilage of a joint depends on its function, immobilisation must be detrimental to the joint. On the other hand a basis for the satisfactory results and great importance of physical therapy is given.

Physical therapy must therefore be included as a necessary part in any treatment of joints since its neglect may have

disastrous effects for the joint's future. If this knowledge can be taken into our medical consciousness there are prospects that it may be possible to counteract many disabling conditions and to make the condition of many patients with joint disorders more tolerable.

For social economic reasons this is of great importance. According to a recent calculation 150 million kronor are lost annually in Sweden due to the disabling effect of chronic joint disorders.

A detailed account of this work will be published in *Acta Anatomica*.

SUMMARY

The author reports an extensive experimental study of joints, which was carried out on 60 rabbits. The animals were divided into a number of groups, of which some were systematically exercised, while others were kept at rest. For the first time it has been shown statistically that in growing animals cartilage responds to increased use by a functional adaptation. Amongst other changes an increase in the cartilage's thickness occurs. This increase affects both the cellular and the intercellular components, but is 4 times greater for the intercellular than for the cellular. The consequences of these findings are discussed from both the theoretical and the practical points of view.

RESUME

L'auteur rend compte d'une vaste étude expérimentale des articulations pratiquée chez 60 lapins. Les animaux ont été divisés en groupes dont certains ont été exercés systématiquement, alors que les autres étaient gardés au repos. C'est la première fois qu'il a été démontré statistiquement que chez les animaux en période de croissance, les cartilages répondent à l'effort demandé par une adaptation fonctionnelle. Parmi d'autres modifications, on constate une augmentation de

l'épaisseur du cartilage. Cette augmentation affecte aussi bien les composants cellulaires qu'intercellulaires, mais elle est quatre fois plus grande pour les intercellulaires que pour les cellulaires. Les conséquences de ces trouvailles sont discutées tant du point de vue théorique que pratique.

ZUSAMMENFASSUNG

Verfasser berichtet über eine ausgedehnte experimentelle Untersuchung an Gelenken, die an 60 Kaninchen ausgeführt wurde. Die Tiere wurden in eine Reihe von Gruppen eingeteilt, von denen einige systematisch geübt wurden, während man die anderen in Ruhe hielt. Zum ersten Male wurde statistisch nachgewiesen, dass bei heranwachsenden Tieren der Knorpel infolge einer funktionellen Anpassung der wachsenden Beanspruchung entspricht. Unter anderen Veränderungen kommt es zu einer Verdickung des Knorpels. Diese Verdickung macht sich sowohl bei den zellularen wie bei den interzellularen Komponenten geltend, ist aber 4 mal so stark bei den interzellularen als bei den zellularen. Die Konsequenzen dieser Funde werden von theoretischen und praktischen Gesichtspunkten aus erörtert.