FROM THE SURGICAL CLINIC I, THE ROYAL HUNGARIAN PÉTER PAZMANY UNIVERSITY OF SCIENCE
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THE PHYSIOLOGICAL OSCILLATION OF THE LENGTH OF THE BODY

BY
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The intervertebral fibro-cartilages form nearly half of the length of the whole spinal column, yet they have received relatively slight attention, being the subject of study in only a few of all the papers dealing with the spinal column. Even the roentgenologist will take no particular notice of the intervertebral fibro-cartilages unless they undergo calcification or become more conspicuous through defects in the shadow of the vertebræ (Ratkóczy, Junghans).

Nevertheless, the intervertebral fibro-cartilages are subject to a good many diseases. In the Schmorl Institute only 266 of 1142 spinal columns which had been divided in their entire length by sawing, showed altogether normal conditions, while pathological changes were found in 879. A majority of these changes involved the intervertebral fibro-cartilages, showing degenerative processes, ossification, vascularization, traumatic breaks, cartilaginous nodosities, and overgrowth of tumors; after the age of 70 years, no spinal column showed altogether normal intervertebral fibro-cartilages.

There is nothing surprising in this, however, when we consider the mechanical hardship to which the spinal column is exposed through a long lifetime. On the contrary, we find not infrequently at autopsy a surprising resistance of the intervertebral fibro-cartilage as evident in cases of aortic aneurysm, mediastinal tumors, etc., where the vertebral bodies are sometimes badly damaged, while the fibro-cartilages appear almost

normal. It happens even sometimes when an autopsy specimen of a part of the spinal column is placed in a fixation fluid for subsequent microscopic examination, that the fibro-cartilages which had been compressed into wedge-shaped structures now within a couple of days assumed the form they had many years ago before the curve of the spinal column was established (Karolini). As a characteristic of the toughness and tenacity of the intervertebral fibro-cartilages it may be mentioned that in fractures of the spinal column the vertebral bodies break not infrequently, but the fibro-cartilages seldom, as demonstrated by Haumann in a great work covering 893 cases.

Not only the great resilience of the intervertebral fibro-cartilages but also the curves of the spinal column play a considerable rôle in the daily oscillations of the length of the body. Apart from the sacral curvature, however, the curves of the vertebral column are not congenital properties but results of a practical adaptation of the body in order to maintain the erect posture. As an element of evolution, walking erect is a relatively new acquirement. It is not yet a hereditary property; the human organism must build it up for its purposes. In the newly born the vertebral column is almost absolutely straight, except for the slight curve of the sacrum. After the fourth month, when the child begins to try to sit up, the curves of the back are forming gradually. First the weight of the chest bends the column forwards; then as the child learns to raise its head by its own muscular efforts, the upper part of the column bends backwards; finally, as the child is learning to walk, the danger of falling headlong makes it force the loins forwards, forming the lumbar curve.

The intervertebral fibro-cartilages play a most important rôle in the forming of these curves; without them the spinal column would make an almost straight line, except for the pelvis.

As to its construction, the intervertebral fibro-cartilage consists roughly of two parts: a lamellated or fibrous ring zone and the pulpy core. These two parts are not sharply defined, however, and their proportional relation is not constant. In old

people the lamellated zone is proportionally larger, and the pulpy core smaller than in children; the core is also firmer in old people.

(In passing, I may mention an American, named Villar, who some years ago visited a great many cities in Europe where he »lectured« before medical societies at the same time as he performed his stunt: »within some seconds he lengthened his body by fully ten centimetres«. Eye witnesses have characterized his performance as an uncanny sight. It is to be regretted that the case was not made the subject of any thorough scientific study. As far as I know, only Kahn has considered this phenomenon from an anatomic-physiological point of view, and he only says that the man had acquired his unique proficiency merely by training the respective muscles in that direction for many years, and by making the most of the innate weakness of the ligaments concerned).

A young man owes his body height largely to a continually swollen condition of his intervertebral fibro-cartilages. In old age the fibro-cartilages shrink and cause a shortening of the body, together with a loss of elasticity.

During the day, owing to the pressure of the body's weight, the intervertebral fibro-cartilages flatten, and this is the reason why a man is not so tall in the evening as he was in the morning; for the same reason he will be shorter while walking a long distance than when lying down. This decrease in height after a long walk is particularly pronounced if he has carried a heavy load at the same time.

When a patient gets up after being confined to bed, he seems to have grown in the meanwhile, because the intervertebral fibro-cartilages now are more swollen than they were at the time he went to bed. In the surgical ward, however, this psysiological phenomenon will often fail to appear because the pain of the illness or post-operative pain will often set up some defensive rigidity of certain muscles; and I have done a good deal of useless work in measuring the height of these patients before realizing the conditional uncertainty of the measurings due to the pain.

We have, therefore, paid more attention to the physiological daily oscillation of the length of the body. We have employed a very accurate scale for this work that will measure any difference, even a fraction of a millimeter, with a high degree of accuracy. Further, all measurings have been carried out at a room temperature of 18° C., or very near this point, so that the measurements have not been influenced by mechanical changes in the instrument due to difference of temperature, nor by otherwise possible changes in the body height from difference of room temperature.

Our material comprises a total of 1216 persons. The youngest was 5 years of age, the oldest 90, and all age-classes are represented by a number of persons sufficient to reduce the possible error to a minimum. It is very important in such studies to measure the individual subject the minute he gets out of bed, for we have ascertained again and again that even walking about on the floor for a few minutes reduces the body height considerably. For this reason we had to carry out the measuring in the bed-rooms of the persons to be meazured, so we had to seek our material in places where a considerable number of persons could be measured immediately after they got out of bed. Further, the noon measuring was always done at a point of time midway between the morning and evening measurings, thus affording a means to ascertain in which part of the day, forenoon or afternoon, the height would decrease the most. The evening measure was always taken at bed-time.

The youngest group in our material is made up of children in the Budapest Orphanage of the Good-Friday Society; an older group comprises children in the Special School for Leather-Industry of Vác and children in the Protestant Orphanage of Budapest. Our adult persons have been inmates of the Elisabeth Home of Budapest, others have been prisoners in the Gaol of Vác. Finally, our old persons have been inmates of the Municipal Home for the Aged.

On summing up the results of our measurings for the total material we have found the daily oscillation of the individual body length to be on an average 15.7 mm., *i. e.*, a much smaller

variation than found by most authors (Fick). The average daily oscillation of the body length in men is 17.1 mm., in women 14.2 mm.

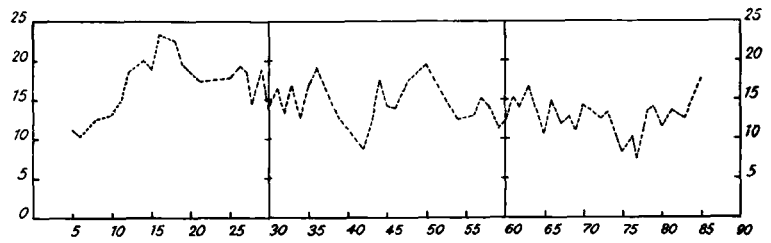

Fig. 1.

Graphical presentation of the average daily oscillation of the body length distributed over age-classes of 5 years, including both male and female persons. The age is plotted along the axis of abscissae, the oscillation (in mm.) along the axis of ordinates.

Fig. 1 gives a graphical presentation of the average daily oscillation of the body length for the total material distributed in age-classes of 5 years, including both male and female persons. It will be noticed that the oscillation is greatest in the second decade; then comes the fourth decade, the third, and finally the fifth decade. The lowest values are found for persons under 10 years and over 50. But even when surveyed in this general manner the material gives a very irregular curve, with great variations in either direction.

If now we divide the material according to sex and construct corresponding curves for both sexes, as shown in Fig. 2, we find that there is hardly any difference in the daily oscillation of the body length in the two sexes in early childhood and in old age. But in the prime of life between the age of 20 and 40 years, men show a greater average daily oscillation of the body length than do women. This may be explained by the fact that in this age period men work generally harder than women, performing a greater amount of physical work, associated with a greater loss of water, which produces in the men a greater daily change in the volume of the intervertebral fibro-cartilages. But even when the material is divided as to sex, the resulting curves show great variations—too great for any definite conclusion.

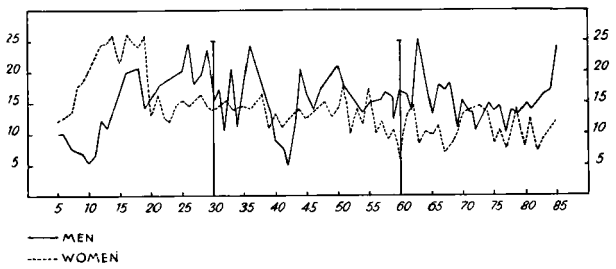

Fig. 2.

Graphical presentation of the average daily oscillation of the body length distributed over age-classes of 5 years, plotted separately for male and female persons.

It would be a mistake, however, simply to accept these curves without further investigation, because then we would be comparing absolute values, although in comparative estimates we may make use of relative values alone. It is only natural that a person over 20 years—and therefore higher than 1.5 metres—will show a greater absolute value for the daily oscillation of the body height than will a person 20 years younger and, consequently, much shorter. But this difference does not lend itself to the comparative estimate here concerned. We have to consider our results in the form of relative values, *i. e.,* we have to figure out for the individual age-classes how much the average daily oscillation of the body length makes in percentage of the average body length of the respective age-groups.. The result of this calculation is presented graphically in Fig. 3, where the age of the persons is plotted along the axis of abscissae, while the ordinates give the daily oscillation of the body length in percentage of the average daily body length. The daily oscillation of the body length is on an average 1.022 % of the height of the body, the average for the males being 1.159 %, for the females 0.884 %. A striking feature of this graph is the fact that the youngest persons show the relatively greatest daily oscillation, and that this value decreases steadily with increasing age. To find an explanation of this we have to analyze the components which determine the length of the body, respectively its oscillation.

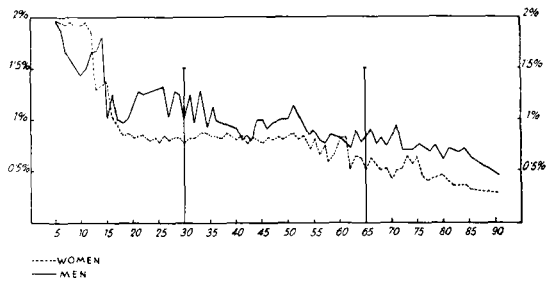

Fig. 3.

Graphical presentation of the average daily oscillation of the body length in percentage of the average daily body length, distributed as to age and sex. The age is plotted along the axis of abscissae; the ordinates give the percentile oscillation of the body length.

The length of the body is the result of three components: the bones, the cartilages between the bones, and the soft parts covering the bones. Any change in length will be due to some change in these components. Among these three kinds of structures, the bone system can modify the daily length of the body only by change in position, while the soft parts can modify the daily height only by daily changes in their make-up.

As even a very slight flexion in some of the joints of the lower extremities may give a considerable difference in the measured length of the body, we have been very careful at each measuring to make sure that each person always keeps the heels in the same position; and the same applies to the end of the great toe. Further, we repeatedly directed each person to »straighten up« completely. It is reasonably safe, I think, to state in these measurings that the position of the lower extremities has taken no part in the outcome of the daily oscillation of the body height. But we cannot claim the same degree of constancy for the physiological curves of the spinal column, and changes in this respect will have to be reckoned as a factor in the daily oscillation of the body height.

The thickness of the soft parts covering the skull and the bone of the heel may be considered constant throughout the day; any possible variation in this respect will be too insignificant to influence the outcome of our examinations.

The third factor in the length of the body is cartilage, and when we keep in mind the great capacity of cartilage for absorption and giving-off of water (amounting up to twenty times its volume), it is obvious that cartilage plays a great rôle in the daily oscillation of the body length.

According to Junghans, the thickness of the intervertebral cartilages is in converse relation to the age of the individual. According to the findings above, the same applies to the daily percentile oscillation of the body length. Junghans has also demonstrated that the intervertebral fibro-cartilages in the newly born are quite equal to the vertebral bodies in height; gradually this relation changes, at the expense of the fibro-cartilages. At the age of 10 years the fibro-cartilage is half as high as the vertebral body; after the cessation of growth—*i. e.*, about the 24th year—the vertebral body is thrice as high as the fibro-cartilage. From then on, the fibro-cartilage decreases steadily: at the age of 60, it is only one-fourth as high as the vertebral body, and it continuesto decrease in the following years.

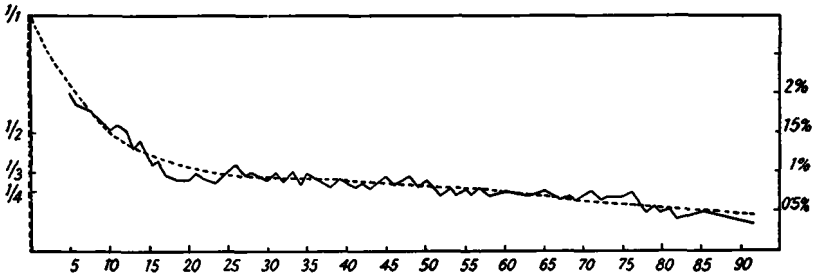

Fig. 4.

Graphical presentation of the thickness of the intervertebral fibro-cartilages in proportion to the height of the vertebral bodies and the daily percentile oscillation of the body length in the various age-classes. The ordinate at the left gives the proportional thickness of the intervertebral fibro-cartilages; the ordinate at the right gives the percentile oscillation of the body length.

Fig. 4 gives a graphical presentation of the thickness of the intervertebral fibro-cartilages in proportion to the height of the vertebral bodies and the daily percental oscillation of bo-

body length in the various age-classes. It will be noticed that the two curves are almost identical. At the ends of the two curves there is perhaps some noticeable difference between the curves, which may be explained by the fact that comparatively little physical work is done in early childhood and extreme old age.

From the findings above, it is evident that the fibro-cartilages may be considered the seat of the daily oscillation of the body length. The cause of this phenomenon is twofold:

1) The physiological curves of the vertebral column become more curved in the course of the day, giving thus a decrease in the length of the body; during the night they recover their original form, which means again a lengthening of the body. The bending of the spinal column, the increase and decrease of its curves, are all expressions of work of the fibro-cartilages between the vertebræ in the sense of statical mechanism. Anterior concavity of the column means compression of the fibro-cartilages, while anterior convexity means stretching. The thicker the fibro-cartilage, the more it will yield to the two forces: pressure and pull. That is why the young with thick fibro-cartilages show a greater daily oscillation of the body length than is seen in old people with the thin fibro-cartilages.

2) It is variations in the water content of the fibro-cartilages that give the daily changes in their thickness, *i. e.,* absorption of water by the fibro-cartilages increases the distance between the vertebræ, and thus the length of the body. But even though the isolated cartilage is capable of such water absorption that it swells to twenty times its original volume (Fick), the daily swelling of the individual fibro-cartilage is relatively moderate. The average daily oscillation of the body length is 15.7 mm., and there are 23 intervertebral fibro-cartilages; this means a maximal linear increase in thickness per fibro-cartilage of 0.68 mm. This half of one millimetre is only one-twentieth of the average fibro-cartilage in an adult man, and the result of such a small physiological swelling of the individual fibro-cartilage is the daily oscillation of the body length, amounting to about 1½ cm.

If we look for practical results of these studies, they will point towards the problem of scoliosis therapy. Scoliosis due to lack of proper balancing between the spinal column and the muscular pull exerted upon it does not necessarily imply any permanent deformity of the vertebræ, nor of the intervertebral fibro-cartilages. We know that the fibro-cartilages easily recover their original form when they are freed from the influence of inhibitive forces; and the long-lasting elasticity of the intervertebral fibro-cartilages gives good promise for any active scoliosis therapy and gymnastic exercises, especially in children and in the young, in whom the fibro-cartilages are yet relatively thick and have an adequate capacity for absorption of water. When first the fibro-cartilages flatten, and the daily oscillation of the body length is less than 1 % of the average length, the probability of a successful therapy vanishes.