THE CONTRIBUTION OF TWIN RESEARCH TO THE PHYSIOLOGY OF EXERCISE

by

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« Physical characters in general are more influenced by heredity than are mental traits as measured by intelligence tests. Motor activity and temperament seem to be least influenced by heredity ». (H. H. Newman, *Twins and Super Twins*, New York, 1942).

Twin research affords an opportunity to study the interplay of heredity and environment. For this reason, twin research is of special interest in the study of physiology of exercise. Genetically, identical twins are the same individual in duplicate because they are the product of a single fertilized egg which splits in half to form two individuals. Non-identical twins are different individuals who through chance were born together. They originate from two different eggs.

Heredity as Determinator of Physique

In non-identical twins, physique may differ significantly because each partner possesses his own hereditary endowment (fig. 1). By contrast, identical twins represent two editions, so to speak, of the same body type (fig. 2). The degree of correspondence of morphological body features in identical, as against non-identical, twins has been statistically assessed by Newman, Freeman, and Holzinger (Twins, A Study of Heredity and Environment, Chicago, 1937).

Table 1

	Percentage of variance due to heredity	Percentage of variance due to environmental and other factors.
Standing height	81	19
Sitting height	76	24
Weight	78	22
Head Length	78	22
Head width	75	25
Total finger ridges	90	10

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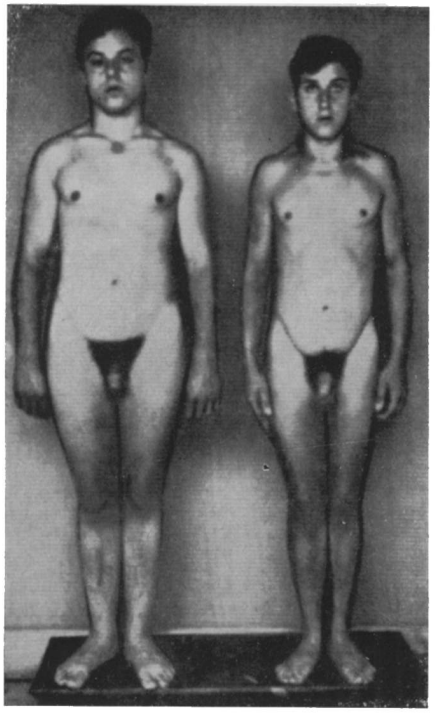

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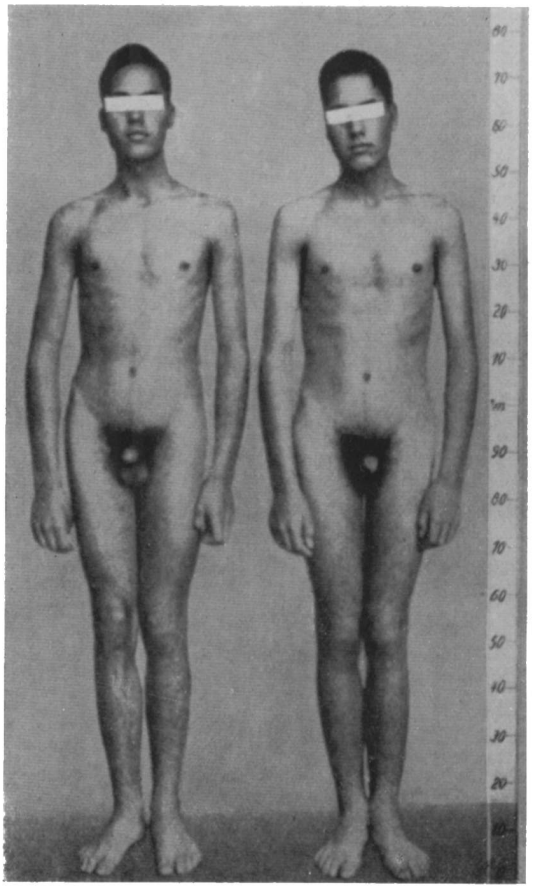

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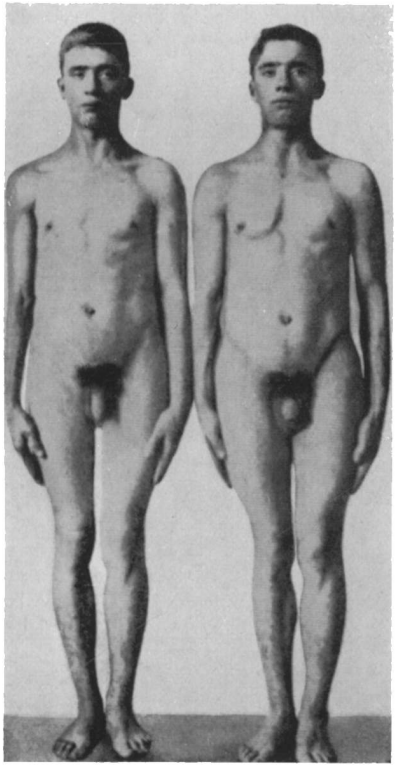

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Fig. 1 - Non identical twins representing two different physical types. (Fig. 1 and 2, kindness, F. Curtius, Handbuch d. Inn Med., Springer, Heidelberg, 1954)

Fig. 2 - Identical twins representing two editions of the same body type

Fig. 3 - Identical twins of which the one on the right has received gymnastic training. (Kindness v. Verschuer, Handbuch d. Erbbiologie, Springer, Heidelberg, 1936)

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Environmental Influence upon Physique

« Environmental factors support, inflect and modify; but they do not generate the progression of development ».
(Gesell, *Proc. Assn. Res. Nerv. and Mental Dis.* 1954)

Because morphological growth follows a predominantly hereditary pattern, environmental influences must be strong to cause major intrageminal or intertwin differences. Twin II in fig. 3 [1] had for several years taken part in gymnastic training. He weighed more and had broader shoulders and stronger muscles than his partner, who had led a physically inactive life. In terms of motor fitness, the trained twin was very much superior to his untrained partner. But the functional inequality was reflected only in comparatively minor morphological discrepancies.

Newman's Cases

Newman reported corresponding observations pertaining to identical twin brothers, age 24, who had been placed in an orphanage when a few months old. They were adopted by different foster parents, neither of whom was told that they were twins. By a coincidence, their relationship was discovered when they were grown up. The one twin, C, was then in much better physical condition because, " he had long been devoted to gymnastic training ", while the brother had done but little manual labor, his work being largely sedentary.

Another pair of identical twins with pronounced differences in muscular development were Mabel and Mary. They had been brought up independently due to environmental influences. " Mabel was a muscular farm worker and Mary a sedentary lady-like music teacher and store clerk. Mabel weighed 138 pounds and was hard muscled; Mary weighed only 110 pounds and the muscles were soft and poorly developed ".

In the above two, as well as in all other known cases of identical twins of whom only one had taken part in physical exercise or otherwise been subjected to muscular training, the genealogical gestalt pattern of physique had remained prevalent in both partners in spite of the environmental differences that were responsible for a divergent development of motor performances.

Heredity and Environment

Most identical twins grow up under identical environmental conditions. It is therefore not surprising that identical twins usually present a striking degree of consonance both in structure and function. In 1952, I examined a pair of identical twin girl students, age 22, at the Sporthochschule in Cologne. Anthropometric measurements, athletic performances, and musical aptitudes were evaluated against a percentage distribution grid constructed from corresponding data collected from 32 physical education students.

[1] After O. von VERSCHUER: *Die Erbbedingtheit des Körperwachstums.* Z. Morphol. 34. 1934.

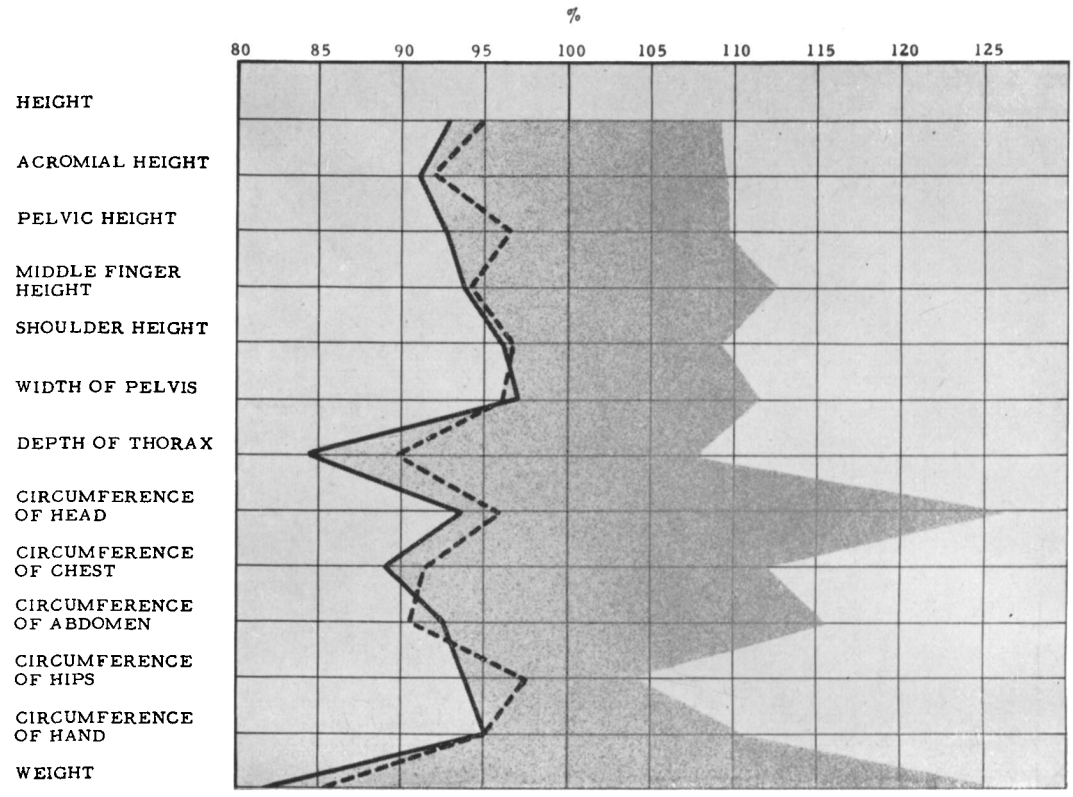
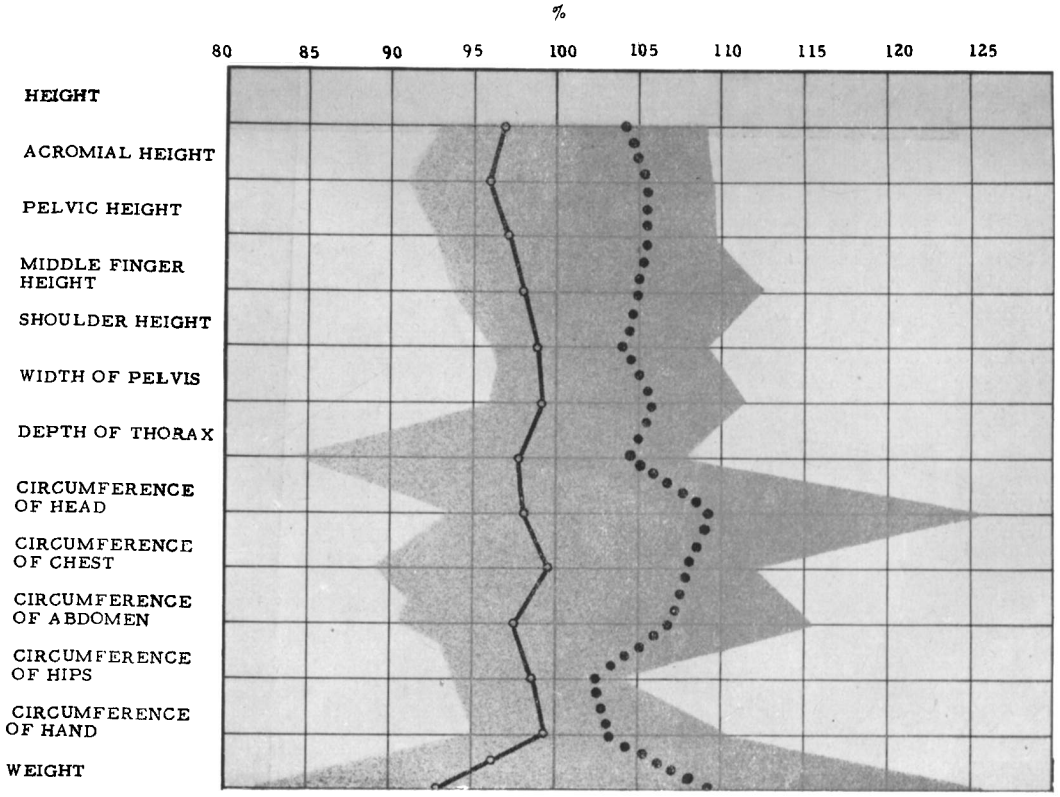


Fig. 4a- - Anthropometric measurements of one pair of identical (*a*) and one pair of non-identical (*b*) twin sisters, evaluated against percentage distribution grid (darkened field) from data collected from 32 physical education students.



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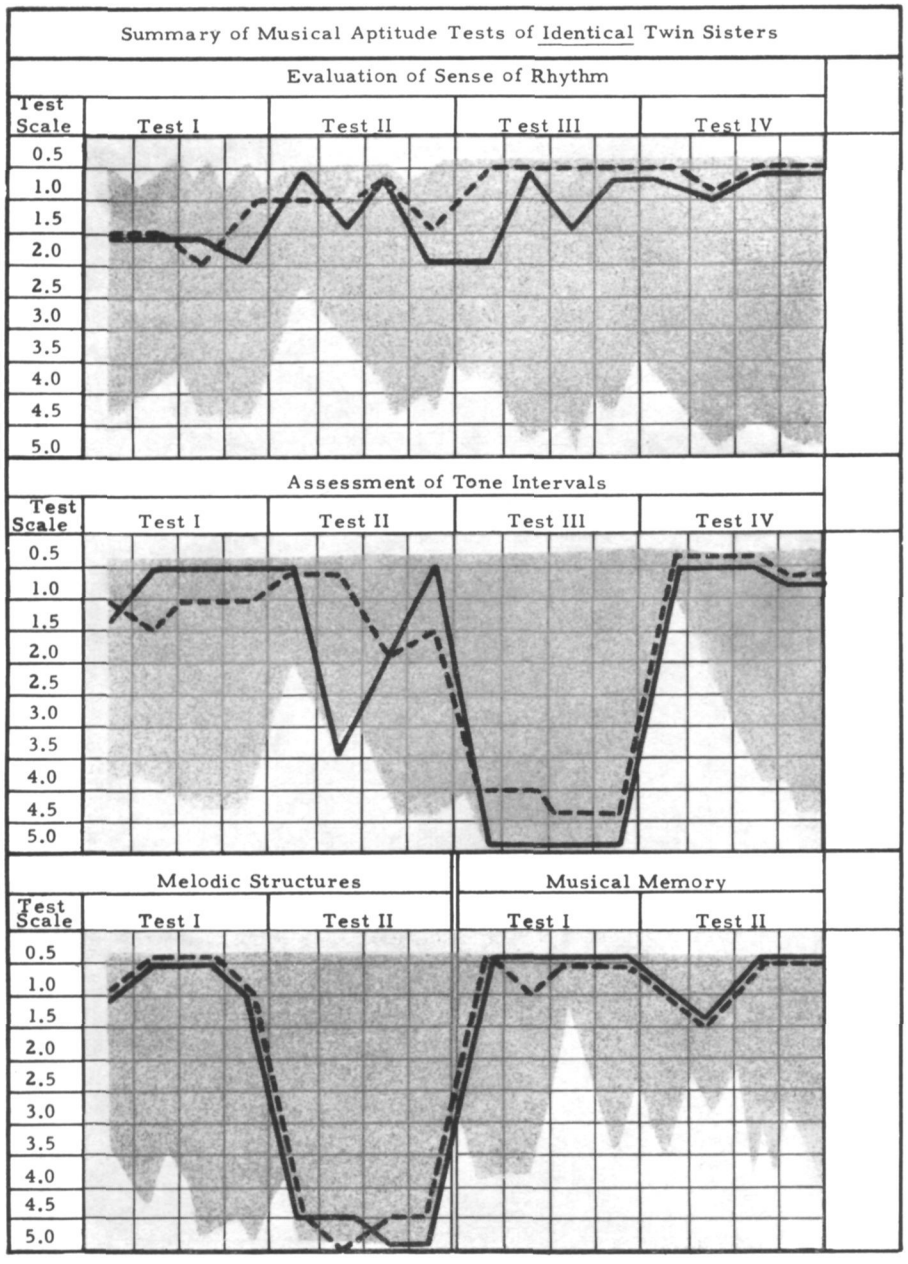

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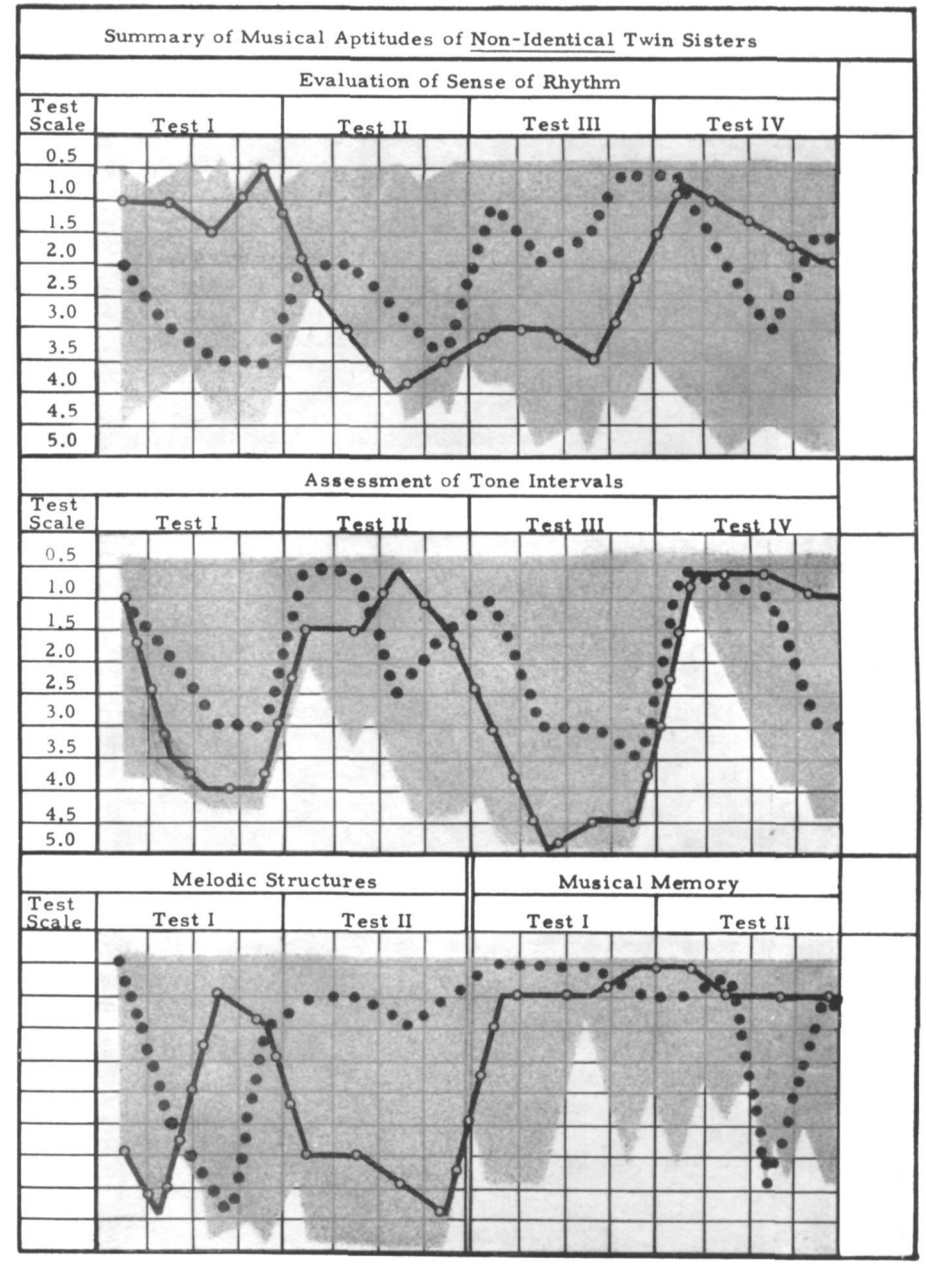

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Fig. 5 - Musical aptitude ascertained by special test battery of one pair of identical (*a*) and one pair of non-identical (*b*) twin sisters, evaluated against percentage distribution grid from data collected from 32 physical education students

Ernst Jokl (A. Ge. Me. Ge., 1, 1956.)
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for 25 minutes daily over a period of six weeks in a situation in which she had an opportunity to climb stairs and to manipulate cubes; twin C served as control. At a later stage, the roles of T and C were reversed.

No significant improvement of skill resulted. At 46 weeks of age, the children simply were unable to comprehend the exercise patterns with which they were confronted. They thus found themselves in a situation which in clinical neurology is referred to as " constructional apraxia ", though this is altogether a normal state in children under one year of age whose movements are governed on reflex basis (fig. 6).

A. N. Mirenva's Study

At four years of age the functional state of the central nervous system allows conceptual appreciation of new motor tasks. Therefore, motor training is now possible. This conclusion was reached by a Russian investigator, A. N. Mirenva, of the Laboratory of Genetic Psychology in Moscow, who reported her findings in the Journal of Genetic Psychology, 1935, Vol. XLVI.

Three pairs of identical and three pairs of non-identical twins, four and a half years of age were studied. Three motor performance tests were applied: high jumping; throwing balls at a target; and bowling. Inter-twin performance differences were significantly greater in the non-identical than in the identical pairs. For the high jump, the differences were 1.75 as against 7.6 cm; for ball throwing, expressed in points, 25 as against 1.47; and for bowling, again in points, 15.0 as against23.8. These data reflect inherent trends; none of the children had so far been subjected to training.

The less advanced and less active partner of each of the three pairs of identical twins was now separated and subjected to physical training for a period of four and a half months. After conclusion of the experiment, the twins who at the beginning of the experiment had been less advanced and less active either equalled or surpassed their previously superior partners (Fig. 7).

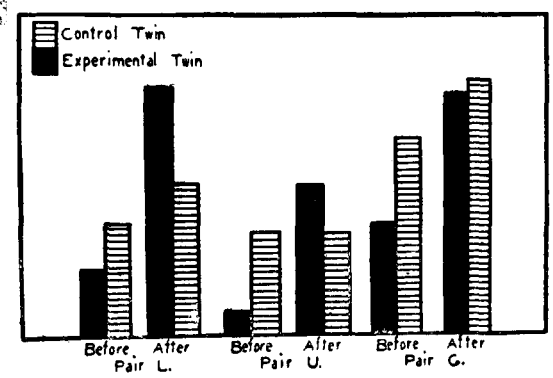

Fig. 7 - (Kindness A. N. Mirenva)

Range of Body Measurements of Champion Athletes

The conclusion that physique is predominantly determined by heredity, while performance depends primarily on training, is supported by another kind of evidence; namely by the discovery that the range of physical measurements of champion athletes

Figs. 4a and 5a reveal a striking similarity of morphological and psychological features of the twin sisters. Athletic and gymnastic performance studies yielded corresponding agreement. The morphological features are near-identical because of the virtually identical environment and education. Such individual differences as are in evidence serve

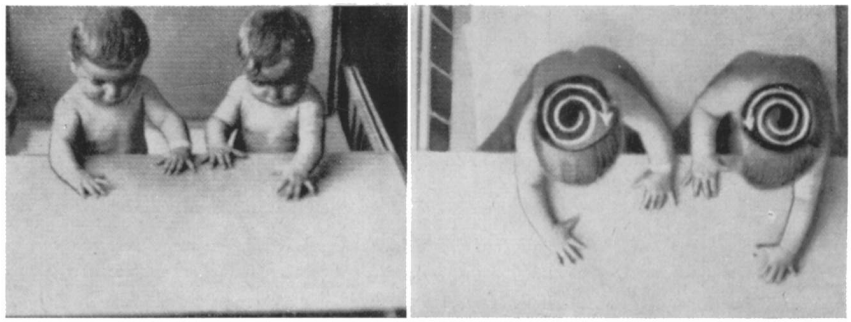

Fig. 6 - Motor behavior in twins T and C., age 46 weeks Similarity of postural and dynamic patterns with mirror imaging indicating contralateral cerebral endowment. (Kindness A. Gesell)

as a reminder that complete correspondence is never encountered, not even in identical twins. At the same time, the magnitude of the differences of the measurements between the non-identical twin sisters (figs. 4b and 5b) represents a measure of the degree of consonance of endowment and of response to extraneous stimuli that is present in identical pairs.

Identical Destiny

How far the identity of destiny in twins can go is shown by the following report that has appeared in the New York Times, of December 28, 1954:

Gelnhausen, Germany. Bob and Bill Denny of Lancaster, Kentucky, are identical twins. They are privates, belong to the same U. S. Army Engineering Company, and are members of the company basketball team. The left leg of each was broken in the same game the other night.

Training Dependent on Comprehension

Arnold Gesell and Helen Thompson, in a study entitled, " Learning and Growth in Identical Infant Twins ", [2] introduced the method of co-twin control into educational physiology. Of a pair of identical twin sisters, age 46, weeks, the one, T, was placed

[2] *Genetic Psychology Monographs*, IV., July-Dec. 1929.

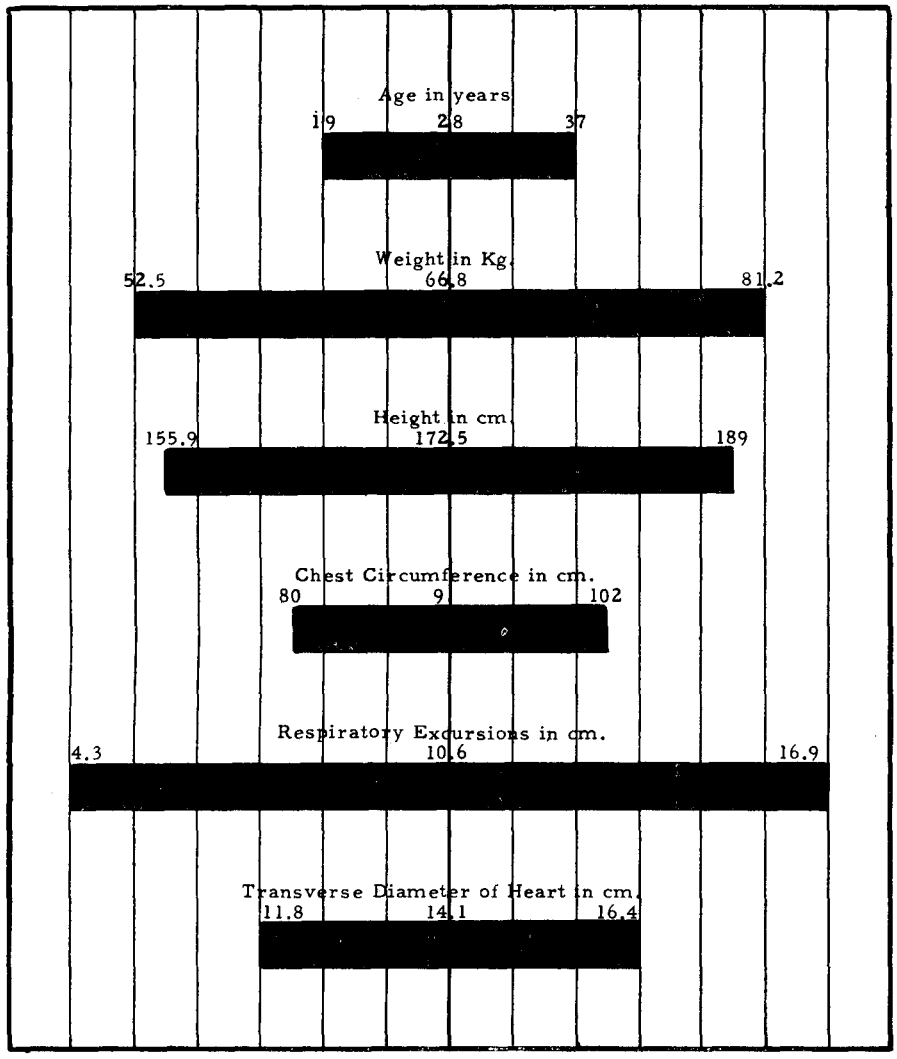

Fig. 8 - The conclusion that physique is predominantly determined by heredity is support ed by thewide range of physical measurements of champion atlheles

is tremendous. As a representative instance, measurements from finalists in the Olympic distance ski races in St. Moritz in 1928 [3] are shown in fig. 8. These observations do not invalidate other findings which prove a correlation between physical aptitudes and certain performances: e. g., between body length and basketball playing and hurdling; between

[3] *Die Sportärztlichen Ergebnisse der II. Olympischen Winterspiele,* Bern, 1928.

body bulk and football or shot put; between low specific gravity and swimming. But, *compared with the extraordinarily high performance level of this group of sportsmen, the scatter of the anthropometric data reveals the plasticity of motor adjustment against the background of morphological variation.*

Injury and Death Associated with Exertion

Among the *clinical* problems that have been clarified through twin studies is that of sudden death associated with exertion. Over a number of years, research papers from my department have detailed relevant evidence.

An investigation with Melzer showed that a high degree of physical efficiency can be maintained in the presence of advanced cardiovascular disease [4]. The observation of two pairs of twins who died, almost simultaneously, during exercise proved without doubt that the pathological changes which underly such tragic events can altogether be an expression of hereditary traits. (Acta Genetica, III, May, 1954). A thirty-two year old international football player died after a strenuous game. [5] Autopsy revealed a comparatively rare condition, viz. status thymico-lymphaticus which is known to form the basis for unheralded fatal collapses. It is characterized by underdevelopment of the arteries, by abnormalities of the blood supply of the kidneys, hypertrophy of the heart muscle, hyperplasia of the thymus gland and of the lymphatic system. *An identical twin brother of the deceased had died the same year while swimming.*

O' Brien, [6] reported the case of a farm laborer, age 26, *who died suddenly while pulling sugar beets.* On post mortem examination a structural abnormality of the left middle cerebral artery was found, viz. a ruptured aneurysm. *A short time before, an identical twin brother of this man had died while playing tennis.*

[4] *S. Afr. J. Med. Sci.*, 1938.
[5] *Am. Heart Journal*, 24, Sept. 1942.
[6] *Brit Med.* J. 16, May, 1942.

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