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Note.—Some figures have been presented without accompanying tables in order to save space. Anyone wishing to have the actual figures should apply to Dr. A. L. Cochrane, the Pneumoconiosis Research Unit, Llandough Hospital, Cardiff.

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A working party of the United Nations Economic Commission for Europe has been studying the prevention of road accidents by action on an international scale. It recommends the formation of an international traffic association to help in the exchange of information. Useful work already done includes arrangements for publication of comparable international statistics on road accidents—the first series, for the year 1953, will be published early in 1954. An international road safety manual is being prepared: the aim is that it should provide a model for national highway codes. The working party also studied safety requirements for road vehicles, with particular regard to brakes, headlights, rear lights, and traffic indicators. A meeting of experts to report on physical, mental, and psychological requirements for drivers was recommended. On the other hand, while admitting the important part played by engineers specializing in traffic problems and the need for a European centre for their training, the working party thought that the time was not yet ripe for the creation of such an institute. The alternative was the international road traffic association, which would bring together road engineers, traffic engineers, police, and other competent authorities.

INCIDENCE OF THE PHYSIOLOGICAL THIRD HEART SOUND

BY

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The beating human heart produces many vibrations of very varying amplitude and frequency. Two series of vibrations are of such amplitude and frequency that they are audible on auscultation of all normal subjects; these are the first and second heart sounds. But we have no right to suppose that these are the only vibrations of constant occurrence during the cardiac cycle.

At the beginning of this century a third heart sound was described by Gibson (1907) and Hirschfelder (1907). This sound was heard in only a proportion of subjects. There is now general agreement that the physiological third heart sound is more commonly audible in young people, but a great diversity of opinion still exists regarding the normal incidence of this sound in various age groups. Table I gives some representative findings of the incidence of the third heart sound in healthy subjects on auscultation.

TABLE I.—*Incidence of the Third Heart Sound in Subjects Without Heart Disease: Auscultation*

Date	Author	No. of Subjects	Age Group (Years)	Incidence of 3rd Sound (%)	Subjects
1909	Thayer	90 55	10–20 20–30	84·4 50·9	Boys, girls, hospital patients, and prisoners
1915–17	Bridgman	16	12–15	81·3	Boys
1926	Steinberg	100	4–14	48·0 95·0*	Children
1926	Gubergritz	600	N	93·7	N
1940	Mannheimer	135	0–14	0·7	Boys and girls
1946	Carlgren	150	3–17	12·0	"
1947	O'Meara	745 255	17–20 21–30	53·6 34·9	Men naval recruits and personnel
1951	Present investigation	123	17–32	9·8	Men and women students

N=not mentioned.
* Direct auscultation without stethoscope.

Einthoven (1907) was the first to note the appearance of vibrations on phonocardiograms at the time of the third heart sound, and these vibrations have since been studied by many workers, using various types of phonocardiograph. Table II gives the incidence of the third heart sound as recorded by some of these investigators.

There is obviously wide difference of opinion regarding the actual incidence of the third heart sound, but most authorities agree that it is detectable on auscultation or by phonocardiography in only a proportion of normal subjects. There are two possible explanations of this. The "sound" may be due to vibrations which are present in only a proportion of subjects: the third heart sound would then be due to a phenomenon of cardiac activity peculiar to certain individuals. Alternatively, the vibrations may be present in the early stages of diastole in all subjects but in many cases are of such amplitude and frequency that they cannot be detected. On this latter interpretation detection of a

third sound may depend largely on extraneous circumstances such as the experience of the observer, the level of background noise in the environment, and indeed on a whole host of factors having nothing to do with the activity of the heart at all. The discrepancies between the findings of different observers rather favour the second alternative.

TABLE II.—*Incidence of the Third Heart Sound in Subjects Without Heart Disease: Phonocardiography*

Date	Author	No. of Subjects	Age Group (Years)	Incidence of 3rd Sound (%)	Subjects
1915–17	Bridgman	16	12–15	100·0	Boys
1932	Leonhardt	41	3–14	83·0	Children
1934	Braun-Menéndez and Orías	100	20–25	60·0	Men students
1934	Clerc *et al.*	33	16–51	33·3	Normal subjects and hospital patients
1935	Pereira	50	18–43	32·0	Pregnant women
1937	Caeiro and Orías	20	N	65·0	Students
1940	Mannheimer	135	0–14	69·6	Boys and girls
1944	Frost	169	N	10·7	Hospital patients
1946	Carlgren	150	3–17	78·0	Boys and girls
1951	Present investigation	123	17–32	40·7* 100·0†	Men and women students

N = not mentioned.
* Logarithmic.
† Linear and stethoscopic.

The modern electronic phonocardiograph, with its great powers of selective amplification, makes it possible to compare all the vibrations produced at the surface of the chest by the beating heart with the audible components of these vibrations.

The object of the present investigation was threefold: (1) To find the incidence of audible vibrations at the time of the third heart sound in a group of healthy young adults. (2) To ascertain whether or not vibrations (audible or inaudible) were produced by the heart at the time of the third sound in all the subjects tested. (3) To find the degree of agreement between observers on the presence or absence of a third heart sound in the subjects examined and the degree of agreement between the findings by auscultation and by phonocardiography.

Details of Investigation

Observers.—Three observers took part in this investigation. All had normal hearing as tested by routine audiometry, but they were of different degrees of experience in listening to heart sounds. Observer 1 (A. S. H.) had practised general medicine for 27 years, with a special interest in cardiology; observer 2 (A. W. S.) had practised for 10 years, again with a special interest in cardiology; while observer 3 (F. W. C.), since qualifying in medicine five years previously, had had little occasion to listen to human heart sounds.

Apparatus.—The binaural stethoscopes employed for auscultation were of a standard pattern with a simple conical chest-piece, 2 in. (51 mm.) in diameter, as illustrated in Fig. 1 *a*.

The phonocardiograph employed has recently been described (Campbell, Sloan, and Andrew, 1952). This instrument can record all vibrations produced at the front of the chest by cardiac activity: such a record is a "linear" phonocardiogram. By the introduction of a length of stethoscope tubing between the standard chest-piece and the crystal microphone, as shown in Fig. 1 *b*, a "stethoscopic" record may be obtained. Finally, by a system of electronic filters, while still retaining the stethoscope tubing, it is possible to introduce selective attenuation of the low-frequency vibrations until the frequency response of the phonocardiograph closely resembles that of the human ear when a stethoscope is used: this yields a "logarithmic" phonocardiogram. A jugular phlebogram was used as reference tracing during each recording, and in each subject an additional record was taken with an electrocardiogram as reference trace.

Subjects.—The subjects of this investigation were students at Glasgow University. At this university all students are encouraged to report annually to the Student Health Service for routine medical examination; during the session 1950–1 30.9% of them did so. In order to obtain as nearly as possible a representative cross-section of the student community every fifth student who reported for medical examination during the Martinmas term (October–December), 1950, was asked to be a subject for this investigation. Out of a total of 125 students who were asked, 123 did offer themselves as subjects, so we feel that our results are reasonably representative of the students as a whole. Of the subjects, 96 were men and 27 women: their ages ranged from 17 to 32 years, with approximately 87% under the age of 25 years. It so happened that none of them had any evidence of heart disease, either primary or secondary.

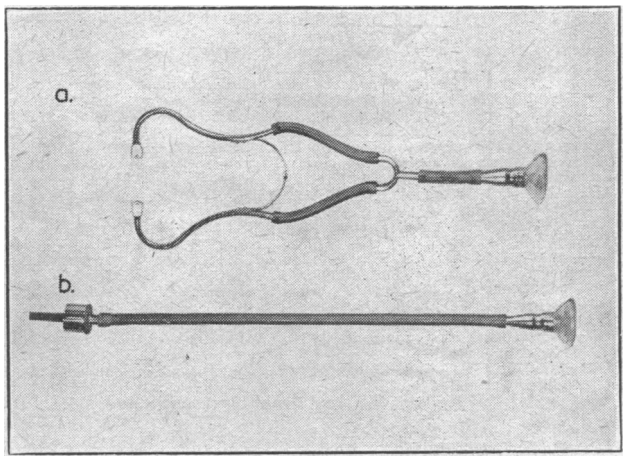

FIG. 1.—Standard stethoscopes: a, for auscultation; b, for phonocardiography.

Procedure

Each subject was listened to by each of the three observers independently, not necessarily on the same day. Auscultation was performed at the cardiac apex with one of the standard stethoscopes, the subject being supine and rested for approximately five minutes. An occasional third heart sound was ignored, but a regularly recurring one was noted as a positive finding.

For phonocardiography the subject was again supine and rested for approximately five minutes. Heart sounds were recorded at the apex with the breath held at the end of expiration.

Measurement of the loudness of heart sounds is at present difficult, but some form of standardization is required: in this investigation, as in that by Luisada and Roitman (1948), the amplitude of the third sound vibrations was measured against that of the first and second sounds. The gain of the amplifier system was adjusted so that the final photographic record of the first or second sound deflections, whichever was greater, was not less than 1 cm. and not more than 2 cm. With this as a standard, any deflection occurring in the position of the physiological third heart sound in at least three successive cycles was taken as indicating the presence of the sound: otherwise the sound was judged to be absent.

The position of the third heart sound on the phonocardiogram was determined by reference to the simultaneous jugular phlebogram. The third sound starts at a time corresponding to the down-stroke or to the foot of the v wave of the venous pulse. This distinguishes it from a split second sound, which occurs before the apex of the v wave (Orías and Braun-Menéndez, 1939), and from an "opening

snap of mitral valve," which starts at the summit of the v wave (Margolies and Wolferth, 1932).

Results

Auscultation.—The third heart sound was heard by a majority of the three observers in 12 cases (9.8%). Observer 1 reported a third sound in 11 subjects, observer 2 in 12 subjects, and observer 3 in 26 subjects. Agreement between the three observers on the presence or absence of third heart sounds was of a low order but definitely significant.

Phonocardiography.—In the phonocardiograms a definite deflection was seen in the expected position for the third sound vibrations in every linear and stethoscopic record from all subjects. In the logarithmic phonocardiograms deflections in the position of the third heart sound were recorded in 48 cases (39.0%).

Fig. 2 shows a typical set of records from a single subject with a third heart sound recorded on the logarithmic phonocardiogram.

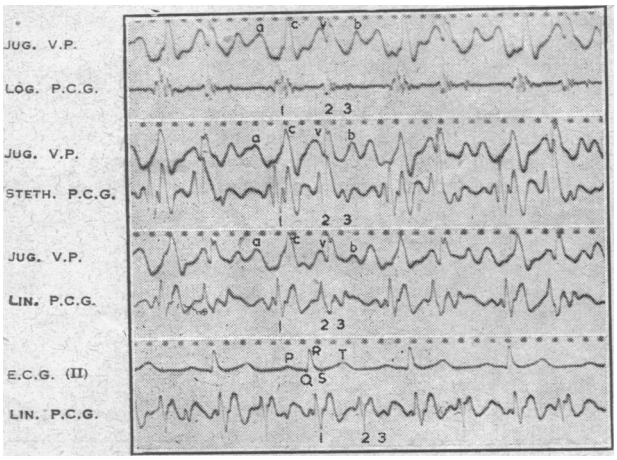

FIG. 2.—Set of phonocardiograms (logarithmic, stethoscopic, and linear) from one subject. Reference tracings, jugular venous pulse or electrocardiogram (Lead II). Time marking in 1/10 second in all records.

Table III summarizes the correlation between the observers' decision regarding the presence or absence of a third heart sound on auscultation and the appearance of a third heart sound on the corresponding logarithmic phonocardiogram. The correlation is significant only in the case of observer 2.

TABLE III.—*Incidence of Third Heart Sound in 123 Young Healthy Adults*

Auscultation Heard by Observers	Phonocardiography (logarithmic)	
	Recorded	Not recorded
None	29	60
No. 1 only	1	1
No. 2 only	3	1
No. 3 only	8	8
Nos. 1 and 2	2	0
Nos. 1 and 3	2	2
Nos. 2 and 3	1	2
Nos. 1, 2, and 3	2	1

Discussion

There is marked disagreement between different investigators regarding the incidence of the physiological third heart sound even in young people, whether the means of investigation be auscultation or phonocardiography.

It is quite clear that in all our subjects vibrations were transmitted to the front of the chest early in diastole during the rapid filling of the ventricles with blood. Only in certain subjects, however, were these vibrations of such amplitude and frequency at the front of the chest that they could be heard on auscultation or detected by a phonocardiograph adjusted to have characteristics resembling those of the human ear.

Further work on the third heart sound must obviously depend on establishing physical criteria for its identification. The ears of clinicians, however skilled and experienced the clinician may be, can hardly be regarded as satisfactory standards of reference. Phonocardiographs, too, are of very different design, and phonocardiography may be misleading unless care is taken to give the physical constants of the instruments used.

Mannheimer (1940) was the first to devise a feasible method for the calibration of a phonocardiograph. Rappaport and his colleagues (1951, personal communication) have made much progress in this direction. Both are able to express the amplitude of the phonocardiogram in terms of absolute units.

Our findings show that future work on the third sound, and indeed phonocardiography in general, would be greatly benefited were some authoritative body to define in physical terms what phenomena are to be accepted as "heart sounds." Then comparisons could profitably be made between the sounds in different individuals, and changes in the incidence and character of the sounds could be followed and interpreted with some confidence.

Summary

In a group of 123 university students aged 17 to 32 years, without evidence of heart disease, a third heart sound was heard by a majority of three observers in only 12 cases (9.8%). On the other hand, deflections occurred in the position of the third heart sound in the linear and stethoscopic phonocardiograms of all the subjects (100%) and in the logarithmic phonocardiograms of 48 of them (39.0%). These results are compared with the findings of previous observers.

Agreement between observers on the presence or absence of the third heart sound was of a low order but definitely significant. There was little agreement between the auscultatory findings and the logarithmic phonocardiograms.

A plea is made for adequate calibration of phonocardiographs so that the results obtained with different instruments may usefully be compared.

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