The Ballistocardiogram in Overweight Young Adults

By SAMUEL STERN, M.D.

(With the technical assistance of Miss Aja Lipavsky)

The ability to record the mechanical function of the heart is the principal value of the ballistocardiogram. In young healthy individuals the ballistocardiogram is consistently normal. Since overweight is apparently an important factor in the development of degenerative heart diseases, a study was undertaken to correlate excess weight in otherwise healthy young students with their respective ballistocardiograms, obtained on a direct-body ballistocardiograph.

The clinical value of ballistocardiography is still limited. There is still considerable discussion as to what constitutes the normal ballistocardiogram, and what are the pathognomonic patterns for specific diseases. There are, however, some general values based on studies with large groups of patients, followed for long periods, that are well documented. Several authors have described the rather frequent occurrence of markedly abnormal tracings among older people. A definitely abnormal tracing, on the other hand, among healthy young adults is an unusual occurrence.

In general one might say that in an elderly patient a normal ballistocardiogram is more helpful to the clinician than is an abnormal one. An abnormal pattern in a young person, however, warrants careful search for cardiac disease, and though no obvious heart disease may be present, the clinician has to be concerned with the prognostic significance of the abnormal tracing.

In this paper a ballistocardiographic study is reported in a group of young adults who, according to the conventional diagnostic tools and clinical criteria, had no cardiovascular disease. The correlation between their ballistocardiograms and physical characteristics is elaborated.

MATERIALS AND METHODS

One hundred and fifty young adults, 100 females from the nursing school attached to our hospital, and 50 males from the University of Cincinnati Medical School were studied. Each subject had undergone a complete physical examination, with particular reference to the cardiovascular system, and was found to be in good health. The upper age limit of this group was 25 years, and a blood pressure not exceeding 135/95 mm. Hg was a prerequisite. An x-ray film of the chest and an electrocardiogram were reported as normal on every subject.

The ballistocardiogram was obtained according to Dock's direct-body method. A commercial Pordy dual ballistocardiograph was used, with a special sturdy wooden table serving as support. The records were drawn over the velocity (electromagnetic) channel, mainly because of the respiratory interference that is more marked over the displacement (photoelectric) channel. The subjects were asked to lie on the bare table with their legs at 45° external rotation. This was found to be the most relaxed position under the circumstances. The crossbar was placed over the ankles, so that the magnet was directly in front of the coils. A distance of a quarter inch was maintained between the magnet and the main body of the machine in the vertical and horizontal planes. The tracings were recorded with a "Simpli-Scribe" (Cambridge) direct-writer electrocardiograph.

Three strips were obtained on each subject: the first during quiet respiration, the second during sustained full inspiration, and the third during sustained full expiration. The ballistocardiograms were interpreted and classified according to Dock's criteria and categories. The minor modifications of Brotmacher were applied. Weights were assessed in accordance with the height, age, frame, and weight charts.

RESULTS

Of a group of 150 records, 23 were found to be abnormal. When classified, 12 of the abnormal tracings were in grade 1, 7 in grade 2, 2 in grade 3, and 2 in grade 4.

When the students were classified according to their weights, 23 were found to be at least 20 pounds overweight, and 21 of the abnormal tracings were in this group. One abnormal
TABLE 1.—Excess Weight Correlated to Ballistocardiographic Abnormality in Young Students

<table>
<thead>
<tr>
<th>Number of students</th>
<th>Over weight (lbs.)</th>
<th>Grades</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>0–20</td>
<td>2</td>
</tr>
<tr>
<td>15</td>
<td>20–40</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>40–60</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>60–80</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>80 &lt;</td>
<td></td>
</tr>
</tbody>
</table>

record was obtained from a normal-weight adult and 1 from a student 6 pounds overweight. Two adults of the overweight group displayed normal patterns.

When the amount of excess weight was correlated with the degree of abnormality in the ballistocardiogram (table 1), the most severe ballistocardiographic abnormalities appeared in the more severely obese students. Thus the data suggest linear correlation between the amount of excess weight and the degree of ballistocardiographic abnormality.

During normal respiratory cycles the inspiratory complexes of the ballistocardiogram were taller than they were during the expiratory phases, as observed by previous investigators. However, in most of our records obtained during full and sustained expiration, the complexes were of higher amplitude than those recorded during full and sustained inspiration or during normal respiratory cycles (fig. 1). We cannot explain this phenomenon, but venture to suggest that the hyperinflated lungs increased the damping factor, while the reverse occurred with the deflated lungs.

**DISCUSSION**

From a theoretical point of view the ballistocardiogram seems to be superior in clinical value to the electrocardiogram. Starr has described the electrocardiogram as the spark for the engine while the actual explosion is being recorded by the ballistocardiogram. The clinician, whose primary interest lies with the mechanical efficiency of the heart, may obtain information from the ballistocardiogram. Yet, from a practical standpoint the ballistocardiogram is rarely used and only on a selective basis. The reasons for this are, first, the relatively young age of ballistocardiography, but second, and mainly, the higher dependency of the mechanical force, as compared to the electric force, on the medium through which it travels. While cardiac function may be normal, peripheral tissue changes with age may markedly modify the spreading vibrations. The main handicap and problem of ballistocardiography seem to be the differentiation between its cardiac and extracardiac components.

In young adults this problem does not exist, yet 23 of our group demonstrated abnormal patterns. Twenty-one of these 23 abnormal records were in young adults with at least 20 pounds excess weight. Moreover, the degree
of obesity was directly proportional to the grade of ballistocardiographic abnormality. One might assume that this is another example of extracardiac factors interfering with the normal propagation of the forces originating within the normal heart. If, however, one accepts Starr’s and Braunstein’s evidence concerning the prognostic value of the abnormal ballistocardiogram, then the results of this paper might serve as circumstantial evidence that early degenerative heart disease is in fact beginning in obese young adults with abnormal ballistocardiograms. Undoubtedly, as with many other problems in ballistocardiography, further follow-up studies will settle this problem. Ballistocardiograms on the overweight patient should, however, be interpreted with reservation. Recent communication with Dr. Braunstein revealed that he has had similar experience with obese patients of the older age group. It is his practice to withhold a definite interpretation in such cases.

The results of this paper reaffirm the importance of the ballistocardiogram in young adults. Excluding the overweight, only 1 of the 150 healthy students displayed an abnormal pattern, and this was of grade 1, abnormality.

**Summary**

A group of young adults under strict criteria for cardiovascular normality has been studied by means of the direct-body ballistocardiograph. The correlation between their weight and ballistocardiographic pattern has been evaluated. It was found that overweight young adults had abnormal ballistocardiograms. This abnormality increased with the amount of obesity. The significance of these findings and their practical application is discussed.

**Acknowledgment**

We wish to thank Drs. F. Donath, T. Levin, J. R. Braunstein, R. Shabatai, and S. Polasky for reviewing this paper.

**Summario in Interlingua**

Un gruppo de juvane adultos, seligite secundo stricte criterios de normalitate cardiovascular, esseva studiate per medio de ballistocardiographia directe. Le correlazione inter le pesos corporee del subjectos e le configuration de lor ballistocardiogrammas esseva evaluate. Esseva constatare que juvene adultos con excesso de peso habeva ballistocardiogrammas anormal. Le anormalitate se accentuava con augmentos del obesitate. Le significazione de iste constataziones e lor application practic es discutite.

**REFERENCES**

The Ballistocardiogram in Overweight Young Adults
SAMUEL STERN and Aja Lipavsky

Circulation. 1958;17:87-89
doi: 10.1161/01.CIR.17.1.87

Circulation is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 1958 American Heart Association, Inc. All rights reserved.
Print ISSN: 0009-7322. Online ISSN: 1524-4539

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://circ.ahajournals.org/content/17/1/87

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in Circulation can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to Circulation is online at:
http://circ.ahajournals.org//subscriptions/