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Effect of Gelatin on Power of Women to Perform Maximal Anaerobic Work.*

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(Introduced by W. J. Meek.)

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Glycine is present in gelatin to the extent of 25%. Its creatinogenic action is the basis for its use in the treatment of myopathies and simple fatigability (Boothby,[1] Wilder,[2] Tripoli and Beard[3]). However, evidence is accumulating which suggests that although the anaerobic reactions of muscle biochemistry involve creatine, such reactions may be little concerned with the performance of exercise in the steady state (Sacks,[4] Flock, Ingle and Bollman,[5] Millikan[6]). It would, therefore, seem highly desirable and possibly even necessary to use maximal anaerobic work in quantitative studies designed to test the influence of gelatin on muscular fatigue which are based upon the creatine-fixing function of glycine. Ray, Johnson and Taylor[7] reported that the daily administration of 60 g of gelatin to each of 6 men for a period of weeks was associated invariably with an increase in work capacity. No appreciable effect was demonstrable when comparable doses of gelatin were given to 4 women included in the study. The rate of work which produced exhaustion within a few minutes, the magnitude of the difference in muscle power exhibited by the male and female subjects, and the sex variation in the response to gelatin were all sufficiently unusual to warrant repetition of the observations made on women.

Methods. The subjects of the investigation were 6 young adult women all of whom had had professional training in physical education and were accustomed to severe physical activity. The exercise was performed on an electrodynamic brake bicycle ergometer equipped with a graphic voltmeter to record rate of working and the speed of

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1 Boothby, W. M., *Proc. Staff Meet. Mayo Clinic*, 1934, **9**, 593, 600.

2 Wilder, R. M., *Proc. Staff Meet. Mayo Clinic*, 1934, **9**, 606.

3 Tripoli, C. J., and Beard, H. H., *Southern Med. J.*, 1938, **31**, 662.

4 Sacks, J., *Am. J. Physiol.*, 1938, **122**, 215.

5 Flock, E. V., Ingle, D. J., and Bollman, J. L., *J. Biol. Chem.*, 1939, **129**, 99.

6 Millikan, G. A., *Physiol. Rev.*, 1939, **19**, 503.

7 Ray, G. B., Johnson, J. R., and Taylor, M. M., PROC. SOC. EXP. BIOL. AND MED., 1939, **40**, 157.

pedalling (Kelso and Hellebrandt[8]). Load and speed were standardized for each subject. Duration of exercise was the independent variable. The subject rode to exhaustion, the end-point for exhaustion being inability to maintain the voltage which served as an indicator of the rate of working. Fig. 1 is a reproduction of a typical record, showing the rapidity with which the voltage rises as the speed of pedalling increases and the constancy with which it is

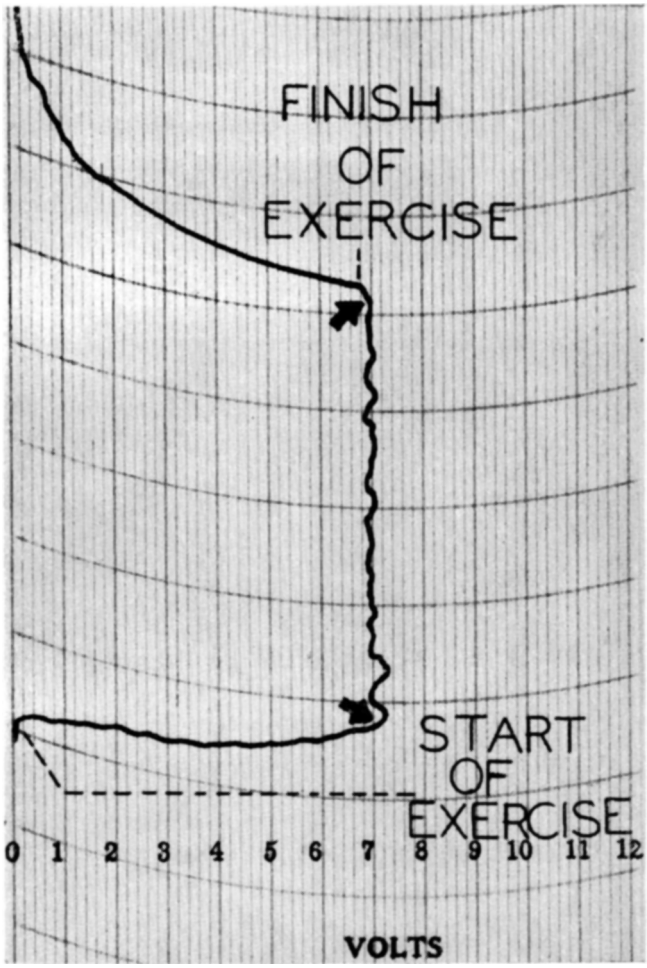

FIG. 1.
Typical graphic voltmeter record obtained on the electro-dynamic brake bicycle ergometer. Abscissae mark time in 10 seconds. Arrows indicate duration of exercise at the standardized rate of working.

[8] Kelso, L. E. A., and Hellebrandt, F. A., *J. Lab. and Clin. Med.*, 1934, **19**, 1105.

maintained once the rhythm is set. Activity ceased abruptly when the rpm necessary to sustain the voltage could no longer be tolerated. Five women worked at a 290 watt *subject output* and one at 220. Exhaustion was usually reached in less than 60 seconds. The duration of the effort in the record illustrated, beginning time at the instant the standard rate of working was achieved, was 45.4 seconds. These findings are in sharp contrast to the data reported by Ray, *et al.*, whose men and women subjects were rapidly fatigued by an *ergometer output* of 60 and 45 watts respectively.

After a period of preliminary training in the performance of rapid violent work standardized as to severity, gelatin was added to the regular diet and then withdrawn as exercise continued. Five subjects ingested 15 g of glycine *per diem,* administered as 60 g of sheet gelatin dissolved and then allowed to solidify in 250 cc of water to which the juice of one lemon and 2 tablespoons of sugar were added. One subject took half the dose in the form of granular gelatin dissolved in cold fruit juice.

Results and Their Interpretation. Fig. 2 illustrates the results obtained upon R. R., an especially well trained subject who had spent the summer preceding the experiment on a cycling tour. Her

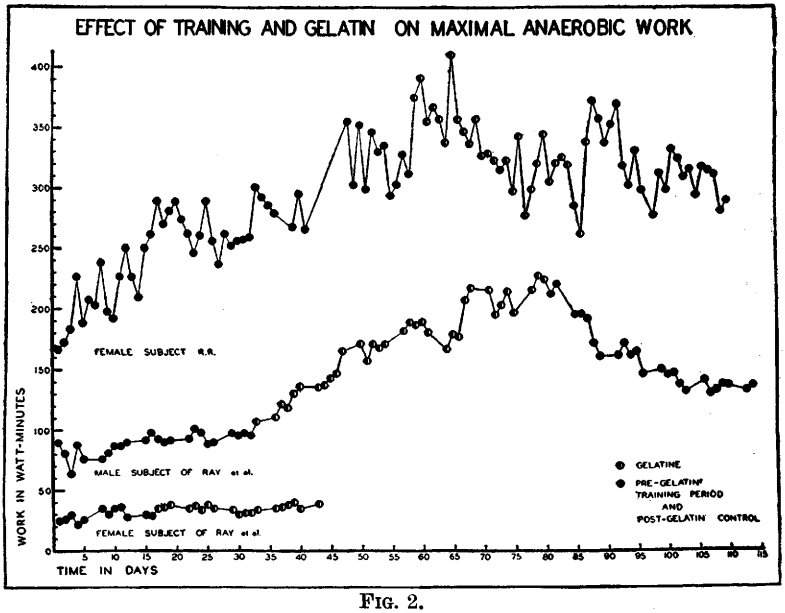

FIG. 2.

Subject R.R. exercised daily. Voltmeter records were not obtained on 8 days. In reproduction of the curves of Ray *et al.*,[7] it was necessary to assume an arbitrary 5 day week so that the number of observations published by them might correspond to the numerical value given for the duration of their experiment in days. This spreads their curve and minimizes the rate of change in power.

ability to perform anaerobic work of extreme severity increased over a period of 65 days. The daily ingestion of gelatin failed to sustain her improving capacity for work. The tendency toward a decrease in power, clearly evident in Fig. 2 (R.R.), may be attributed to "staleness." Though short-lived, the work was so rigorous that recovery may have been incomplete in 24 hours. No athlete can repeat a record-breaking performance daily. Transient increases in power occurred both at the beginning of the administration of gelatin and at the onset of the post-gelatin control period. No matter how well trained the subject, it is never possible to completely eliminate psychic influences in experimentation involving human beings performing work to exhaustion on devices not driven by forces beyond voluntary control.

For purposes of comparison, the only data reported for a woman by Ray, Johnson and Taylor[7] and those obtained on their male subject demonstrating the best effect attributed to gelatin are also reproduced in Fig. 2. Henderson and Haggard[9] estimated the maximal power of Yale Olympic oarsmen as 0.56 horse power in a short race lasting 6 minutes. The power developed by R. R. was 69% of that demonstrated by these men. This compares favorably with Dawson,[10] who estimates that the maximum energy which can be exerted by a woman is approximately 72% that of a man. The power developed by the male subjects of Ray, *et al.*, was 0.08 horse power, a rate of working which could be rapidly exhausting only if carried on at excessively high speeds. Subject R. R. rode at 98 rpm. In our experience, pedalling rates beyond 120 are self-limiting because of incoördination.

Fig. 3 illustrates the effect of introducing gelatin at different phases of the training period. Subject B. McL., slight in build and weighing 52 kilos, exhibited the greatest improvement with daily exercise and attained the highest work output in our series. The administration of gelatin relatively early in the experiment may be interpreted as having had no effect upon the trend of the training curve which rose steeply from the beginning to the end of the experiment. Her power to perform work oscillated more widely than that of R. E. B., whose training curve was closely approximated by our remaining subjects although gelatin was administered to them as early as to B. McL. The data presented in Fig. 3 suggest that gelatin neither affects the capacity to do more work as a result of repeated

9 Henderson, Y., and Haggard, H. W., *Am. J. Physiol.*, 1925, **72**, 264.

10 Dawson, P. M., *The Physiology of Physical Education*, 1935, Baltimore, The Williams & Wilkins Co.

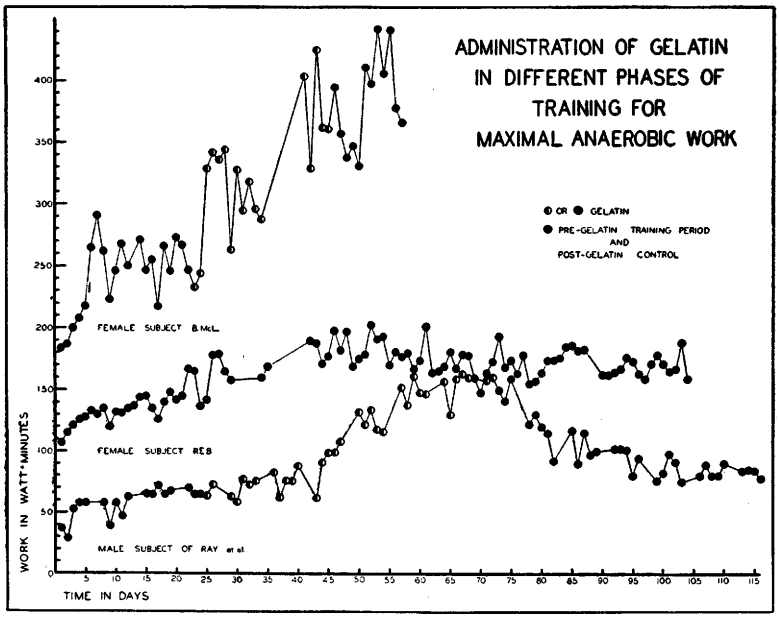

FIG. 3.

Voltmeter records were not obtained on days in which gaps occur in the curves of B. McL. and R.E.B. They exercised daily. In this figure as in Fig. 2, the 5-day week is arbitrarily used for graphing the data of Ray *et al.* against time.

activity, nor prevents the development of chronic fatigue (R. E. B.) when the activity is too severe.

The gelatin ingested was added to the regular diet, increasing its protein content by one gram or more per kilo *per diem*. Wishart[11] showed that the performance of a long distance racing cyclist was best on high protein diets. Mirski and his associates[12] have recently shown that the blood sugar and fuel reserves of the liver laid down on a protein-rich diet behave differently from those deposited on a diet of carbohydrate. Such observations suggest that gelatin might be advantageous in the performance of protracted hard work.

Summary and Conclusions. Physical exercise, maximal anaerobic in type and constant as to the rate of working and speed, was performed to the point of exhaustion by 6 healthy young adult women. After a period of preliminary training varying in length in the different subjects, gelatin was added to the diet and its influence upon the time of onset of muscular fatigue was noted. The evidence presented substantiates the following conclusions. Gelatin has no effect

11 Wishart, G. M., *J. Physiol.*, 1934, **82**, 189.

12 Mirski, A., Rosenbaum, I., Stein, L., and Wertheimer, E., *J. Physiol.*, 1938, **92**, 48.

upon the capacity of women to perform maximal anaerobic work, nor any apparent effect upon the improvement in power due to training. Gelatin does not prevent the development of "staleness" when brief work of extreme severity is repeated daily over a long period of time. A comparison of the published data of Ray, *et al.*,[7] with that of our series of experiments suggests that the increase in work output attributed by these investigators to gelatin may also have been a training effect.

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Further Approach Toward Control of Spontaneous Cancer of Mammary Gland in Mice by Heptyl Aldehyde-Sodium Bisulphite.

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Evidence has been presented that demonstrates quite convincingly that the growth rate and fate of spontaneous carcinoma of the mammary gland in mice may be significantly influenced by heptyl aldehyde.[1] The effect of liquefaction (both partial and in some cases complete) together with a slower growth rate and complete disappearance of the tumor mass could be brought about by the introduction into the organism of the drug either by the diet or by subcutaneous injection (at areas remote to the spontaneous tumor). One of the limiting factors in the introduction of the material

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1 Strong, L. C. PROC. SOC. EXP. BIOL. AND MED., 1932, **30**, 386.