THE EFFECT OF ISOMETRIC TRAINING ON THE LEG STRENGTH OF WOMEN SPRINTERS

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Abstract

Three potentially international calibre women sprinters were given an eight weeks' isometric strength training programme for their legs, using 80% maximum strength as the loading factor. In an attempt to reduce decrement subsequent to cessation of training, a four week 'taper' programme was tried. Strength measures were taken fortnightly through the training programme and subsequently at three months and nine months on one athlete. Strength gains were obtained for all athletes and the post training decrement appeared to vary with the muscle group exercised. No detrimental aesthetic, emotional or physiological effects of the high loading were noted and no injuries occurred.

Introduction

In athletic events which require that great strength be used quickly as in the so-called 'power' events such as jumping, throwing and sprinting, the value of intensive weight training is fully, and almost universally, appreciated. On the other hand, for events in which muscular endurance and general cardio-respiratory condition are paramount, such as in the long distance track events, weight training is used considerably less frequently and, when employed, often appears in a modified form.

Considerable discussion has centred on the load which the athlete should be using in his weight training programme. The perennial argument between the light load with many repetitions and the heavy load with a few repetitions has been more or less resolved with a utility found for each method. The development of isometric training has re-focussed the discussion more towards the determination

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of the most effective weight which can be used as a 'heavy' load for isometric purpose. Experimental evidence for this optimal loading, in terms of per cent maximum strength, has indicated a considerable span from which a choice may be made. But whatever the loading used for men, in women's athletics there appears to be a general suspicion and fear of heavy loading for reasons varying from the aesthetic to the para-physiological.

The present report is of a study undertaken in 1962 on three young women athletes who specialised in the short sprints and hurdles. The coach¹ of these three potentially international calibre women athletes, believed that strength was a fundamental requirement for sprinting and that isometric training appeared to be a promising method of rapidly developing strength. In discussions of similar programmes which had been used in Western Australia, with other athletes (4), rowers and rehabilitation cases (5), the high loading which had been employed was emphasised, as was the author's interest in maintaining such a loading with women athletes. The coach agreed to the proposal to run the three athletes as an experimental group to see what the effect would be on their strength and on their subsequent performance².

From the now copious work in the field of strength development the likely improvement was expected to be of a similar order to that in the literature. For this reason a second area of interest was investigated in an attempt to combat the almost inevitable fall off in strength subsequent to the cessation of training. Therefore as far as strength development was concerned, two points of interest occurred in the study - the response of the women athletes to a high overload isometric training period and any delay which could be induced in the strength decrement subsequent to the cessation of the programme.

Method

Three young women athletes were the subjects for this study, two (aged 17 years and 21 years) specialised in the 100 and 220 yards sprints and their metric equivalents whilst the third (22 years) was specifically an 80 metres hurdler.

1. Mrs. Shirley de la Hunt, better known in the world of Olympic Athletics, as Shirley Strickland.
2. From an experimental standpoint this was a minor consideration as in the circumstances the isometric training programme could not be established as a contributing agency to the performance as it was but a part of an extremely thorough general sprint training and control groups did not exist.

The movements selected for isometric training were ankle plantar flexion, knee extension, hip extension and hip flexion. Measurement of the isometric strength of these movements were taken in principle from the method outlined by Clarke (1), and all measures were taken with the measuring cable at right angles to the appropriate limb. During the initial measuring session it became quite evident that the extra suppleness of the women was going to be a major problem. For this reason a number of modifications had to be made to the techniques.

Ankle Plantar Flexion

For ankle plantar flexion a metal plate 9" long, 2" wide and $\frac{3}{8}$ " thick was used against the sole of the foot to act as a brace and the belt was passed around the plate and the foot at its broadest part. The angle between this plate and the table was adjusted (usually about 85° proximal to athlete) to allow for the stretch in the webbing stays so that at maximum effort the angle was 90° . The subjects' shoulders were braced by padded rests secured to the head of the table. It was found that the exercising leg tended to abduct during vigorous effort and there was also a pronounced tendency for the pelvis to lift off the table associated with hyperextension of lumbar spine. These movements were restrained by strapping the athlete to the table by leather belts 8' long, $2\frac{1}{2}$ " wide and $\frac{1}{4}$ " thick, one over the iliac crests and another over distal tibia and fibula of both legs.

Fig. 4. Hip Extension

Fig. 3. Hip Flexion

Fig. 2. Knee Extension

Fig. 1. Ankle Plantar Flexion

Figure 1

Knee Extension

For knee extension each subject was measured with the top of the leg strap placed 10" below the medio-anterior border of the head of the tibia. The knee and hip angles were at 90° and the hands grasped the edge of the table level with the hips, with the elbows locked. Leaning backwards was not permitted. Padding in the form of foam rubber was necessary under the exercising knee.

Figure 2

Hip Flexion

Hip flexion was measured on the table as in Figure 3. The hands were placed back from the edge of the table and the elbows fully extended. The foot of the non-exercising leg rested comfortably on a small bench. The measuring strap was placed on the exercising leg such that the distal margin of the strap was barely proximal to the femoral condyles. The angle at hip was established at 90° .

Figure 3

Hip Extension

Hip extension was measured on a modified ergograph as in Figure 4.

Figure 4

The strap was attached to the thigh with the distal border just clear of, and proximal to, the condyles of femur. The angle at hip was 70° . There was a tendency for the athlete to arch her back and also to lift her free leg during the exercise. These movements were countered by strapping the athlete (iliac crests and ankle of free leg) to the platform upon which she worked. During the programme another problem arose because of the heavy loads the girls were using.

As the strength of hip extension increased, mechanically it became easier for the athlete to lift herself and the platform to which she was strapped, rather than the weights set as load. It therefore became necessary to load the platform beyond the athlete's feet to counter this tendency.

The same equipment was used for the exercise programme as was employed for the testing. For the exercise programme instead of the measuring cable terminating on a fixed point on the apparatus as in the strength tests, it was run over a pulley which was also attached to the apparatus, and thence to a cradle resting on the floor. By varying the weights which were placed on the cradle an adjustable load was possible.

Each athlete was provided with individually tailored cables for each of the four exercises. These cables were adjusted such that when the athlete attached one end of the cable to the cradle, ran the cable over the appropriate pulley, attached the other end to the limb strap and then took up the correct position for the specific exercise, the cable was taut. A single effort then consisted of increasing the tension in the cable (by exercising the appropriate muscle group) until it was sufficient to lift the load clear of the floor by one inch and then to hold it there for the 5 second period.

Training Programme

The athlete's schedule was highlighted by two competitions, in mid October the National Championships and six weeks later the VIIth British Empire and Commonwealth Games. Before the National Championships a period of fourteen weeks was available, of which the first two weeks were spent in manufacturing the cables. It was decided to use a period of eight weeks' intensive training consisting of five efforts at each exercise done twice per week with a retest and reloading done fortnightly. This was followed by a 'taper' period of one month where the number of efforts required were 3, 2, and 1 twice a week and finally 1 effort once in the last week. A final test was to be taken at the end of this taper period.

During this isometric strength training period the girls were undergoing six days per week track training including a competition on Saturday. It was thought that track training should continue during the strengthening programme as it was felt essential that the girls should be continuously absorbing into their running action any additional strength which would be likely to develop through the isometric programme. Also for this reason it was decided to try to stabilise the strength for the National Trials and the Commonwealth Games rather than continue to develop it right up to the date of the first track meeting. It was considered better that the athletes could use all of a sub-maximum percentage of their potential strength without loss of running technique rather than have that style, and possible efficiency, disrupted by ill-harnessed strength.

It was with this basic schedule that the three young women athletes began their isometric training programme based on a loading factor of 80% of maximum strength.

Results

The strength measures obtained in the different movement for each of the athletes at the succeeding testing sessions have been graphed and appear on pages 69 and 70.

Discussion

There was a most marked response of the ankle plantar flexors to the form of isometric exercise and the degree of loading used in this study. Percentage improvement over the twelve weeks' period ranged from 78.5 to 97.5. The strength data for J. B. showed an early attainment of maximum which was maintained during the full programme and apparently during the taper period. M. B. on the other hand showed continued though decreasing improvement through the period and it was unfortunate that illness prevented final testing, as it would have been interesting to discover whether the improvement was maintained during the taper period. From the data of J. B. and M. B. however it was noticeable that the latter seemed likely to reach a maximum below the 400 lbs. of J. B. J. D. had strength data for ankle plantar flexion which had characteristics of both J. B. and M. B. in that the figures for the right leg attained an early maximum (350 lbs) which was maintained by both the intense and the taper programmes, whilst the data for the left ankle indicated a steady improvement throughout the experiment until the final testing figure was 390 lbs. J. D. specialised in hurdling in which she led with her right foot thereby relying on left leg drive to take her over the hurdle. Was her leading leg preference because her left leg was capable of greater development than her right or, in fact, was it that because of her style that the difference in strength potential was determined?

For hip flexion (Knee Lift) gains of 50.0 to 147.1% were recorded. The greatest gain occurred with J. D. (hurdler) who also started with the lowest figures. It seemed that J. B. and J. D. attained roughly the same level of 200-210 lbs. and had a possibility of improving further. M. B. on the other hand showed a considerable tendency to cease improving early in the training and although her initial improvement was the most rapid her final level appeared likely to have been below those of the other two athletes. One interesting feature was the straight line improvement of J. B. (left leg) and the increasing response with time which appeared with her right leg. However, both achieved a final score between 200-205 lbs. In all three athletes the strength developed during the intensive programme did not seem to be lost during the taper period.

The results of hip extension were limited to two athletes J. B. and J. D., as soon after commencing the programme M. B. suffered a recurrence of an old abdominal muscle injury whilst training on the track and it was decided to discontinue the isometric hip extension exercises in her case because of the discomfort the injury produced during this exercise. Initial readings of

Graph. 2. Strength Measures taken over Developmental Programme

160 lbs (left) and 155 lbs (right) were obtained for M. B. who recorded a 207 (left) on the first retesting but on reaching 200 during the testing of the right limb then pointed out that her abdominal injury was causing sufficient discomfort to influence performance. The other two athletes improved steadily during the intensive training period but this could not be maintained during the taper programme during which time performance actually fell below the peak level obtained at the end of the training session. It therefore seems likely that to maintain the level of hip extensor strength which can be developed during isometric training, relatively more effort must be demanded from this muscle group than from the others under similar conditions. Maximum improvements obtained at the end of the intensive training period ranged from 37.2 - 55.5% and these had fallen to 8.7 - 41.9%, the greatest decrement being associated with the athlete who had the greatest gain during the training period proper.

The data on knee extension strength showed that both sprinters (J. B. and M. B.) had a gradual but continuous improvement throughout the intensive and taper programmes. The improvement was only marginally different from linear and total gains of from 43.5 - 83.4% were observed for the two athletes³. Once again J. B. showed the greatest improvement. J. D., the hurdler on the other hand, showed a fairly typical gain during the initial period but this soon diminished and, in the case of the right leg, strength appeared to fall off during the last third of the intensive programme and during the taper period. In her case maximum improvements were, for the left leg 40.0% whilst for the right, the maximum was also 40.0% but was attained two thirds way through the intensive training period, and this had fallen to 28.6% by the end of the full training and taper periods.

Relation to Track Performance

The training period was during the winter and spring of an equitable climate (as indicated by the meteorological data in Table 1.)

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3. If the graph for M. B. were extrapolated, the lower level of improvement would have been increased to 52.2%.

Table 1

Climatic Conditions in which Athletes Trained*

*By courtesy of Deputy Director, Bureau of Meteorology, Perth

	1962						
	June	July	August	Sept.	Oct.	Nov.	Dec.
Mean Min. Night Temperature of	52.3	46.3	49.3	48.5	49.8	56.6	63.3
Mean Max. Day Temperature of	66.4	63.9	65.6	67.4	68.1	76.1	84.4
Mean Sunshine in Hrs. per day	3.9	6.1	6.2	8.2	8.7	9.4	10.0
Total Rainfall in inches	5.98	6.06	3.40	2.46	2.08	1.51	0.53

Simultaneously with the isometric strength programme the athletes were undergoing a thorough track training. Comparing performance with strength can only be done for interest as this experimental design does not justify the testing of a hypothesis of relation.

During this period the times of M. B. improved regularly, e.g. best times in July were 11.0 secs. for the 100 yards and 25.1 secs. for the 220 yards. In November for the same distances her times were 10.4 secs. and 23.8 secs. Her stride length also increased by 2 inches. M. B. was of average build and possessed an excellent running action. J. B., on the other hand, was younger, somewhat stronger and had a much more robust style of running. Her times improved during the winter and spring but did not surpass those of M. B. Unfortunately no details were available on the stride length of the other athletes. J. D. (already the Australian 80 metre Hurdle Champion) had a slight build and maintained a high standard of performance.

In mid October at the end of the taper period all three athletes travelled 2,105 miles by rail to Melbourne for the Australian Championships which on this occasion also served as the VIIth Commonwealth Games selection trials. On the two days of the sprint trials (13th and 14th October) the weather was said to be cold, windy and wet⁴. The track was reported as water-logged on both days whilst on the first day the standing surface water was being swept off the track.

4. The actual climatic data supplied by courtesy of the Bureau of Meteorology at Melbourne was for 13/10/63 (3.0 p.m.) and 14/10/63 (9.0 a.m.) respectively - temperature 57.0°F. and 54.5°F; humidity 92% and 64%; wind speed and direction, SSW 11 m.p.h. and SSW 19 m.p.h. (maximum gust for period, SSW 36 m.p.h. at 8.30 a.m. 14/10/63); rainfall in previous 24 hours, 16 points and 47 points.

J. D. was placed third in the final of the 80 metres Hurdles in a much slower time than she had been consistently attaining during training in Perth. M. B. was sixth in the 100 metre final, having been third in her heat in 11.2. She won her heat of the 220 yards in 25.0 seconds and ran third in the final with a personal time of 25.3; all times she had consistently beaten in Perth conditions. J. B., on the other hand, in running times of the order of her training performances was placed first in 200 metres (25.0 secs.) and third in 100 metres (11.2 secs.).

Both J. M. and M. B. were selected for the Australian Women's Team for the VIIth Commonwealth Games and J. D. was unfortunate to miss selection. In the international competition in late November J. B. obtained a Silver Medal in the 200 metres (time 24.2 secs.) and M. B. obtained a Bronze Medal also for the 200 metres (time 24.5 secs.). Both athletes were selected in the 4 x 110 metre relay which recorded a time of 46.6 secs. to gain the Gold Medal.

In the months after the Commonwealth Games M. B.'s times returned to their previous standard, December, 75 yards in 8.5 secs., 100 yards in 10.5 seconds, and 220 yards in 24.0 seconds. In January exceptionally fast times were achieved, 60 yards in 7.1 secs., 60 metres in 7.3 secs., 75 yards in 8.2 secs. (world's best performance) and 220 yards in 23.2 seconds (world's best performance)⁵. In each of these performances J. B. ran a close second.

On January 10th 1963, M. B. returned to the laboratory for testing to discover what proportion of her strength-gain remained after three months without any weight training. As her abdominal injury had interfered with the hip extension programme only three movements were measured and the results appear in Table 2.

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5. It is salutary to note that the worst time M. B. recorded in a competitive 100 yards race during the three months following the Commonwealth Games, was better than the winning time in that international meeting.

Table 2
Strength Measures on M. B.

		<u>Pre Isometric Training</u>	<u>End of Isometric Training</u>	<u>Final Test</u>
		<u>July 1962</u>	<u>Sept. 1962</u>	<u>Jan. 1963</u>
Ankle Plantar	right	192	370	345
Flexion	left	196	360	315
Knee Extension	right	117	163	115
	left	115	170	118
Hip Flexion	right	112	180	190
	left	115	195	180

In this one athlete, of the 50-60 lbs. extra strength developed in knee extension during the Isometric Programme during the subsequent three months without this training effectively all of this strength had been lost. Of the extra 170 lbs developed in ankle extension only 15-25% had been lost in similar circumstances. Apparently none of the 70-80 lbs. additional hip flexion strength gained during the isometric programme was lost. Hypothesising from the fall off of hip extensor strength of the other two athletes during the taper period it seems likely that the additional strength in this movement would also have been lost in the three months. Quadriceps is notorious for its alert response to the exercise demands placed upon it but it is an interesting conjecture to explain why one muscle group retains a new strength level which has been achieved under artificial conditions whilst other muscle groups return partially or completely to pre-training levels.

This work was continued by Mr. D.J. Glencross⁶ and when a modified programme was resumed in August 1963 preliminary measurement of ankle plantar flexion for M. B. was 264 lbs for both left and right leg. Nine months after the cessation of isometric training programme it might have been thought that strength could have returned to the pre-training level of approximately 200 lbs. The fact that this had not occurred in this instance might imply that M. B. now uses this strength level in her sprinting, thus maintaining the strength level. Alternatively it might support the view (236) that a considerable skill factor exists in the actual strength measure itself and which is recalled easily in the testing situation.

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Probably both factors are contributing in this case.

Conclusions

In this study an objective isometric programme involving a high (80% maximum) loading factor was used on three women sprinters. Strength gains as indicated by periodic retests were obtained and these varied from individual to individual and between the various muscle groups exercised. Whether this strength gain reflects true hypertrophy, increased neuromuscular co-ordination or both was not discussed though it was felt that some of the retention of strength after a nine month lapse in isometric training might reflect some improved neurological organisation of the movement. Apart from increasing the strength scores, the high loading factor did not appear to affect the athletes aesthetically, psychologically or physiologically. The extra flexibility of the girls had to be catered for and, in this study, injury during the weight training programme did not occur.

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