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UTILITY OF THE POWERBALL® IN THE INVIGORATION OF THE MUSCULATURE OF THE FOREARM*

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ABSTRACT

In order to ascertain the utility of a 250 Hz NSD Powerball® gyroscope in increasing the maximum grip force and muscular endurance of the forearm, ten adults without pathology in their upper limbs exercised one forearm with the device during a period of one month. We evaluated grip strength and forearm muscle endurance with a Jamar dynamometer both at the end of the month as well as after a resting period of one month. There was a tendency (not statistically significant $p = 0.054$), for the volunteers to increase their maximum grip strength. There was also highly significant increase in muscle endurance ($p = 0.00001$), a gain that remained slightly unchanged after the rest. Because the gyroscope generates random multidirectional forces to the forearm, the reactive muscle contraction is likely to stimulate more efficient neuromuscular control of the wrist, a conclusion which our work appears to validate. The use of Powerball® in forearm proprioception deficient patients is, therefore, justified.

Keywords: Gyroscope; Grip Force; Endurance; Proprioception.

INTRODUCTION

In most sports, as rehabilitation of different pathologies of the upper limb, there is a need for incrementing force of the musculature of the forearm. Several devices with fixed weights have been created for different muscular groups to work with: cuff links and bars, bands of tension, jetty pincers. Not long ago, an apparatus appeared in the market, developed to carry out exercises of muscular build-up of the upper extremity, based on the principles of gyroscope.[1,2] It is a hollow sphere that contains in the interior a rotor of 200 grammes of weight with an eccentric mass located two centimetres away from its axis. This internal cylinder rotates around an axis which is perpendicular to the main axis. The internal rotor moves not so much as a result of its fixed weight (single weight 280 grammes) but by the generated centrifugal force. When the internal rotor is accelerated, generates a torsion force that causes a turn in the perpendicular plane, and because the eccentric disposition of its mass, a rotational force to the rotor is generated up to 10,000 revolutions per minute. The gyroscope accelerates by means of movements of wrist rotation. As the speed of the rotor of the gyroscope increases, the centrifugal force increases and, therefore, the necessity of muscular control becomes increasingly bigger. This work was designed in order to ascertain if this device induces significant changes in both the maximal grip strength and muscular endurance, understanding this last factor is the most important parameter in most activities.

MATERIAL AND METHODS

Ten adults, five men and five women, participated in this study. None had antecedents of traumatic lesion or pathology in both

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Fig. 1 250 Hz NSD Powerball®.

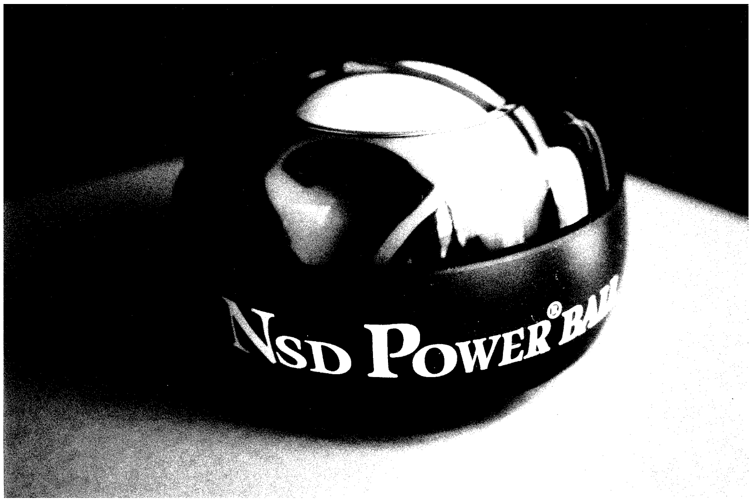

Fig. 2 Another view of the 250 Hz NSD Powerball®.

upper limbs and were not carrying out any other build-up plan during this project. Each volunteer was given a 250 Hz gyroscope (NSD Powerball®). The study was divided into two periods of four weeks each. The volunteers exercised the dominant upper extremity in two daily series of three minutes in the first two weeks and two daily series of five minutes in the last two weeks. In the second period they did not carry out any muscular invigoration. The exercise was performed while seated, with the elbow flexed at 90°, and leaning on a firm surface. Rotation of the gyroscope was driven with wrist turning clockwise in case of the right arm dominant volunteers and counter-clockwise in case of left-handed volunteers. In all cases, the overall wrist envelope of rotation was set around a slightly extended-ulnar deviated position, and always trying to develop the maximum possible speed that could be maintained and controlled comfortably during the whole exercise. The contralateral upper limb did not carry out any build-up work and it was used as the control. Each person was given a chart to document the exact timing and incidences of all their exercises.

Evaluation of Force

Both upper limbs were assessed before and after the first period of exercises, and again after a month of rest. The grip strength

Fig. 3 Powerball ready to work.

Table 1 Maximal Grip Force and Endurance Index Results.

Volunteer	MaxGF (Initial) kg.	MaxGF (1st Mth.) kg.	MaxGF (2nd Mth.) kg.	Ei (Initial)	Ei (1st Mth.)	Ei (2nd Mth.)
(A)	29	44	40	16	24	31
(B)	28	35	37	15	39	20
(C)	51	63	53	18	36	31
(D)	41	52	55	24	41	48
(E)	56	54	57	18	29	37
(F)	35	36	30	15	29	32
(G)	26	24	19	10	33	24
(H)	37	31	33	13	39	26
(I)	21	30	30	11	16	11
(J)	56	60	52	17	30	28
Average	38	42.9	40.6	15.7	31.6	28.8
Median	36	40	38.5	15.5	31.5	29.5
SD	12.7	13.6	13	4	7.7	9.9

MaxGF: Maximal grip force, Ei: endurance index, SD: standard deviation.

was measured with a Jamar® dynamometer[3] in the position two or three depending upon the patient's comfort. With the shoulder relaxed, the elbow flexed at 90°, the forearm leaning on the examination table in neutral forearm rotation and the wrist extended at 25.°[4] To obtain maximum grip force the volunteers were requested to compress the two bars of the dynamometer as hard as possible, alternating both hands. The highest reading from three attempts was used in this study.

To evaluate muscular endurance,[5,6] we established the following assessment method. The volunteers were asked to alternate periods of three seconds of maximal contraction with three seconds of relaxation until the digital reading was equivalent to 40% of the maximum grip force determined earlier. The number of contractions above that level was used as an expression of muscular endurance of each individual.

The participant volunteers were not informed of their results until all assessments were finished. All tests were monitored by the same investigator.

The Student's t-test for matched samples was used to settle down differences in the studied parameters between the two arms, and a p-value of < 0.05 was utilised as the threshold of significance.

RESULTS

The average maximum grip force (MaxGF) of the dominant hand prior to the exercise period was 38 kg [range 21–56; standard deviation (SD): 12.7], and the average muscular Endurance Index (EI) was 15.7 contractions (range 10–24; SD: 4).

After the first period of one month exercising regularly with the gyroscope, the average MaxGF was of 42.9 kg (range 30–63; SD: 13.6). This corresponds to an increase of 15% as compared to the initial determination, and although the gain was not significant, the tendency for an increase in this parameter was clear ($p = 0.054$). The average EI was 31.6 contractions (range 16–41; SD: 7.7) representing an increase of 109%, which is highly significant ($p = 0.00001$). After the same period the non-dominant arm did not increase either in MaxGF ($p = 0,45$) or in EI ($p = 0,065$).

After the second period of one month where no exercises were carried out, the average MaxGF diminished slightly down to 40.6 kg (range 19–57; SD: 13), although that decrease of 5.3% was not statistically significant with regards to what was achieved at the end of the first period ($p = 0.17$). Similarly, the average EI decreased down to 28.8 contractions (range 11–48; SD: 9.9), but that 7.7% reduction was not statistically significant ($p = 0.36$). Not surprisingly, the differences between the initial and final recordings of both MaxGF and EI remained highly significant ($p = 0.00001$).

DISCUSSION

The results of this study appear to prove the hypothesis that regular use of a gyroscope for one month does not develop the capacity of maximum contraction of the musculature of the forearm but increases its endurance substantially. Indeed, the increment of the number of contractions beyond a certain level after a month of exercises was remarkably high. Furthermore, it appears to remain high for an extended period of at least one more month of not using the apparatus. As this last parameter is one of the most trustworthy ones for the evaluation of muscular invigoration, it is apparent that gyroscopes may have a role in our future treatment armamentarium. Contrary to other more static devices, the gyroscope generates forces in different directions, in a quite random way, forcing the musculature of the forearm to react in an unpredictable way, thus stimulating proprioception. In these regards, this device may be found particularly useful in patients with congenital or acquired hyperlaxity having developed wrist dysfunction secondary to poor proprioceptive neuromuscular control.

Although debatable, we believe that the muscular control that is required to counteract the centrifugal forces generated by this sort of apparatus is in fact an eccentric exercise, inducing active fibre elongations.[7–9] In other words, this sort of exercise does not imply a reduction of the muscular fibre length as when the extrinsic activity of the muscle is propitiated.[9]

Needless to say, although this device may be useful for rehabilitation of different pathological conditions, it should be used carefully. Although none of the volunteers experienced significant pain nor discomfort with its use, the generated force may become quite important and, as shown in different studies, eccentric exercises in weak or improperly trained musculatures have potential for a higher pain index and damage of the muscular ultrastructure.[10,11]

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