SHORT-TERM INCREASE OF EXPLOSIVE STRENGTH THROUGH MAXIMAL ARBITRARY CONTRACTIONS

THE RELATION OF NEUROLAN INVOLUTION

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Problems and Aims

Previously published contributions have presented results that indicated improved explosive strength improvements in upper and lower extremities through a few maximal arbitrary contractions (MVC's) for several minutes (Gullich/Schmidtbleiclt 1995). In a study of bench pressing the movement time for each 4mm of the press was recorded before and after performing MVC's. This data allowed tracing the force-time relationship. Figure 1 shows that the maximal arbitrary contraction before the bench press were responsible for a positive adaptation, in particular as far as strength was concerned. Similarly, maximal isometric leg press repetitions were responsible for a short-term improvement in the performance of countermovement depth jumps.

It was assumed that the positive results occurred mainly from the mechanisms of post-tetanic potentials (PTP). The existence of this nerve to nerve transition for several minutes had been proven in several experiments with animals. It had been further shown that the PTP effect can also be produced with a physiological stimulation frequency (Lev-tov et.al. 1983; Lusher et.al. 1983; Cossard et.al. 1994).

When this kind of an effect could be produced in the neuro-muscular system of humans, the positive effects of an arbitrary activation of the neuro-muscular system should considerably influence explosive strength (Schmidtbleicher 1987). Maximal voluntary contractions would activate motor units with a stimulus from tetanic frequencies exceeding 100Hz. However, Hutton (1989) claimed that it is not possible to explain satisfactorily that the PTP stimulates in humans the pool of motor neurons.

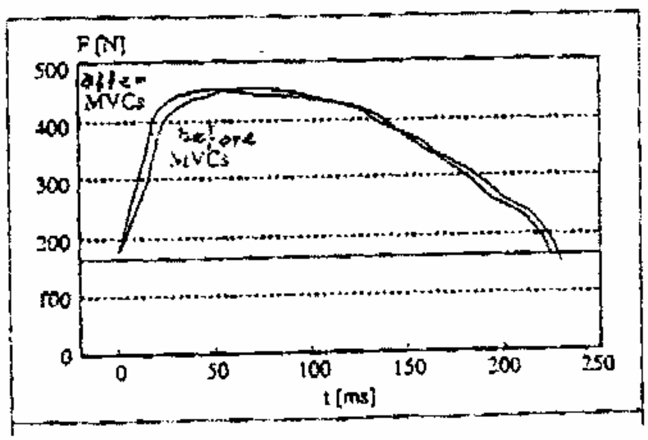

FIG. 1: Graphs of F/t in the bench press before and after 2 MVC's. Median values of 5 attempts (n = 30).

Consequently, the aim of the following study was to prove that the neural effects in humans can be created by using MVC's and how much the speed-strength increases are connected to the PTP mechanisms.

Study method

The subjects of the study were 10 trained speed-strength athletes (ATHL) and seven physical education students (SPST), who did not take part in regular weight training. H-reflex of the M. triceps surae (TRS) before and after maximal arbitrary contractions were determined to evaluate modifications in synaptic efficiency, as well as the input-output relationship in the alpha motoneurals pool.

Certain nerve tracks can be irritated in the stimulus of Nitibialis. The impulse is from one of the alpha motoaxons transferred directly to the neuro-motor endplate from the other mainly Ia fibres, where the analogous for the stretching reflex is switched on alpha motoneurals. The single stimuli solve at the neuro-motor endplate two problems. Their summarized action potential at M.triceps surae can be tracked from a electromyograph. The M-wave after about 5ms and the H-reflex after roughly 30ms (Fig. 2). The centre of interest in this study is directed to the H-amplitude changes at a constant stimulation which reflects modifications in the number of recruited motor units.

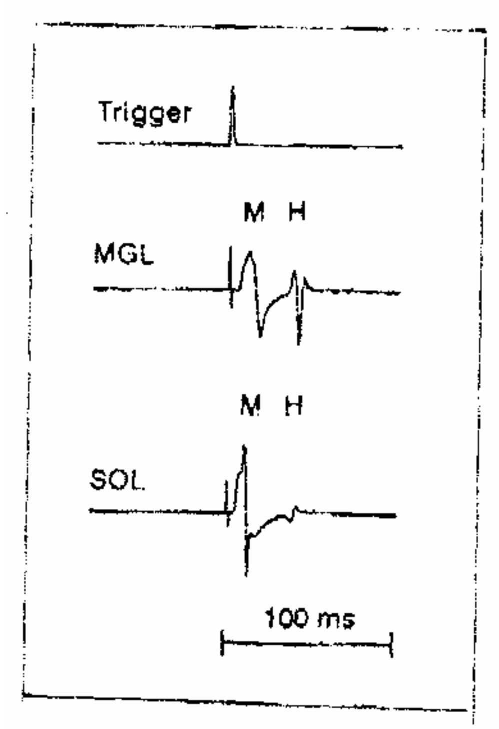

Fig. 2: EMG of the M and H reflex answers. The N. tibialis is stimulated through the skin. The stimulus is guided direct to the neuro-motor endplate and Ia fibers, where it is analogically switched to motoneurons, as well as alpha motoaxons, to be guided to the neuro-motor endplate The summarized action potential gives two separate answers in the M-wave after about 4ms and the H-wave after about 30ms. The test parameter is amplitude of the H-reflection.

The test procedures required alter a warm-up the placement of a stainless steel electrode on the knee joint, The subject were situated on their backs on a gymnastic mat. The involved leg was placed straight on a 22cm high box with the sole placed at a right angle on a force plate and the head and shoulders supported.

The stimulation for each subject was established so that the highest possible activation level of the H- reflex answer of the M. gastrocnemius lat. (MGL) was secured. The H-reflex was every 5s over one minute before and every second minute, up to 13 minutes, after MVC’s recorded. The test parameter was the median amplitude of 12 attempts. The reliability of the test took place in two control minutes and provided in tt .99 a high reliability coefficient.

The second step in the study attempted to examine how far the MVC produced modifications to the speed-strength parameter with the raised neural parameters vary. The above outlined speed-strength tests had shown positive adaptations. For this reason it was attempted here to observe the behavior of the explosive strength. The M. triceps surae was chosen because the H-reflex attempts were also conducted with this muscle. The subjects were requested with their sole of the feet to produce the highest possible explosive strength on the force plate. Sets of three attempts with a 30s recovery were performed before and each second minute, up to 13 minutes, after the maximal arbitrary contractions. The test parameter was the sharpest force increase, based on the median value of the three attempts. A control series revealed a tt reliability of .97.

Results

We will now look at the reflex amplitudes and values of explosive strength of the voluntary contractions for the single collection stages. These include the maximal post MVC (peak H, peak Fexp) as well as their time points. The measured data of the results are normalized for each subject (control value = 1).

Typical EMG's of an athlete can be seen in figure 3. The total group showed after the treatment contractions a passing H-reduction in M. Gastrocnemius lat. (post-tetanic depression, PTD). The rehabilitation on the reflex answer exceeded considerable the control amplitude (Fig. 4). The spread of the time point peak H indicates strong individual variations in t peak H=8.7±3.6 min (range 2.5 to 12.5 min). A reliability check with five athletes repeated the test and produced a median reliability coefficient of tt=.91.

A comparison could be made of the behavior of both M. triceps surea, M. gastrocnemius lat. and M. soleus in nine athletes. The developments were similar (r=.84), although the PTP in M. soleus was smaller (peak H SOL= 1.20 ± 0.20 (20% potential), peak H MGL=1.32 ± 1.32 (32%) and shorter in duration (peak H SOL 5.6 ± 4.0 min.). There also were differences between the speed-strength athletes of national class (ATHL) and the physical education students (SPST). The potential in M. gastrocnemius lat. was in trained speed-strength athletes considerably higher and lasted longer (4 to 13 min, $p<0.5$, fig. 5). Similar tendency applied to M. soleus, although differences between the two groups could not be statistically secured.

In the voluntary plantar flexion appeared in the speed-strength athletes a passing reduction of explosive strength after the MVC's. The following strength increase reached between the second and third minute again the control level and exceeded it significantly from the fourth to the thirteenth minute, ($p<.05$). The peak Fexp was 1:19±0.14 (19% potential), the tpeak Fexp 9.0±3.5 min (range 4.5 to 12.5 min.). This means that explosive strength also shows individual differences in time.

Figure 6, however, shows a close intra-individual common variation of the speed-strength components with the H-amplitude. The time points of t peak Fexp and tpeakH correspond ($r = .89$). The correlations of both characteristics produced a median coefficient of $r = .90$. The behavior of the M. soleus reflex amplitude varied in a similar manner with increased strength, although the correlation was slightly lower (r = .75).

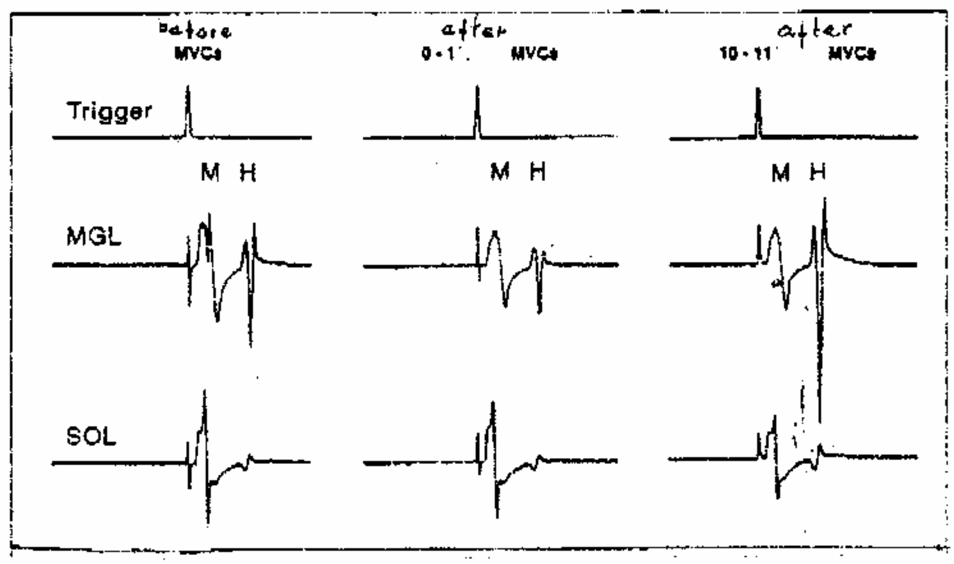

FIG 3; Typical H-reflex EMG s of the M. triceps surae before and after 5 maximal arbitrary contractions (national class sprinters)

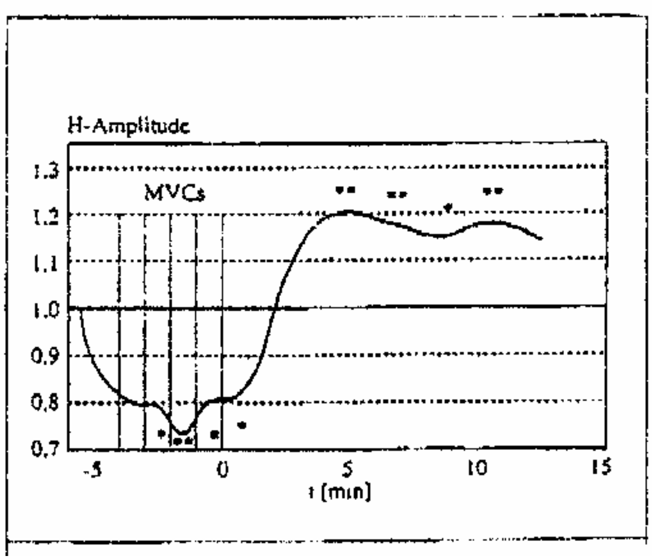

FIG 4: The graph of the H-reflex amplitude of M' Gastrocnemius lateralis. Difference to control values; p<.05, p<.01. n±17

Discussion

The results indicate clearly that more motor units are activated through MVC's. The additionally recruited motoneurons should, according to Henneman's "size principle", activate more units after MVC's at a next, higher level. It follows that the potential effect, proven here for the reflex answer, is also valid for an increased central arbitrary activity (Burke 1981). The presented data therefore indicates that the stimulus of alpha motoneural pools coincides with an increased arbitrary motoric development of explosive strength. There are common variations in both of these characteristics.

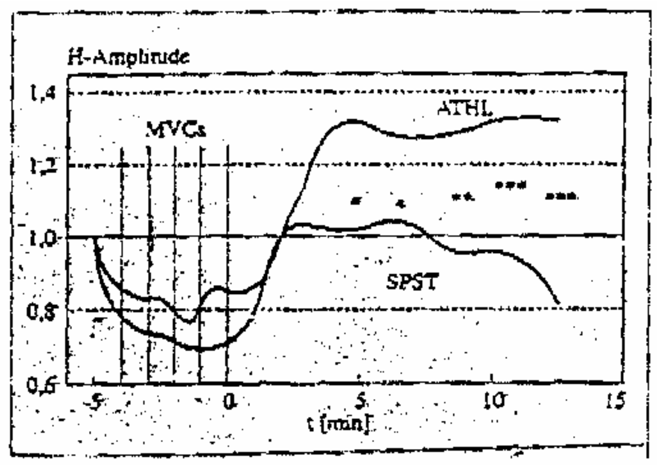

*FIG 5: Graph of the H-reflex amplitude of the M. gastrocnemius lateralis for speed-strength athletes of national class (group ATHL, top line, n =10) and physical education students (group SPST bottom line, n = 7). Group differences: *p<.95, **p<.01, ***p<.001*

The mechanisms of the PTP are not yet completely explained. However, there is a common agreement that a raised synaptic efficiency can be explained by continuing accumulation of calcium in the pre- and post synaptic cells (Luscher et.al. 1983; Eccles, 1983; Fisher and Johnson 1990; Gossard, et.al. 1994).

The established differences in the PTP effects on the M. gastrocnemius lat. and M. soleus correspond to the results recorded in animal experiments, showing a strong positive relationship of potential with the size of motor units. This result can possibly assist in the interpretation of the differences between speed-strength athletes and physical education students.

Further, not all motor units can normally be activated in arbitrary muscular contractions. There is an autonomously protected recruiting reserve, made up mostly of fast twitch muscle fibers. The arbitrary neuro-muscular activation capacity is therefore the ability to activate the largest possible number of units and to recruit them as fast as possible at the start of a contraction. The rise of a neuro-muscular activation through MVC's makes it possible to activate the autonomous reserves, in particular the fast twitch fibers reserves.

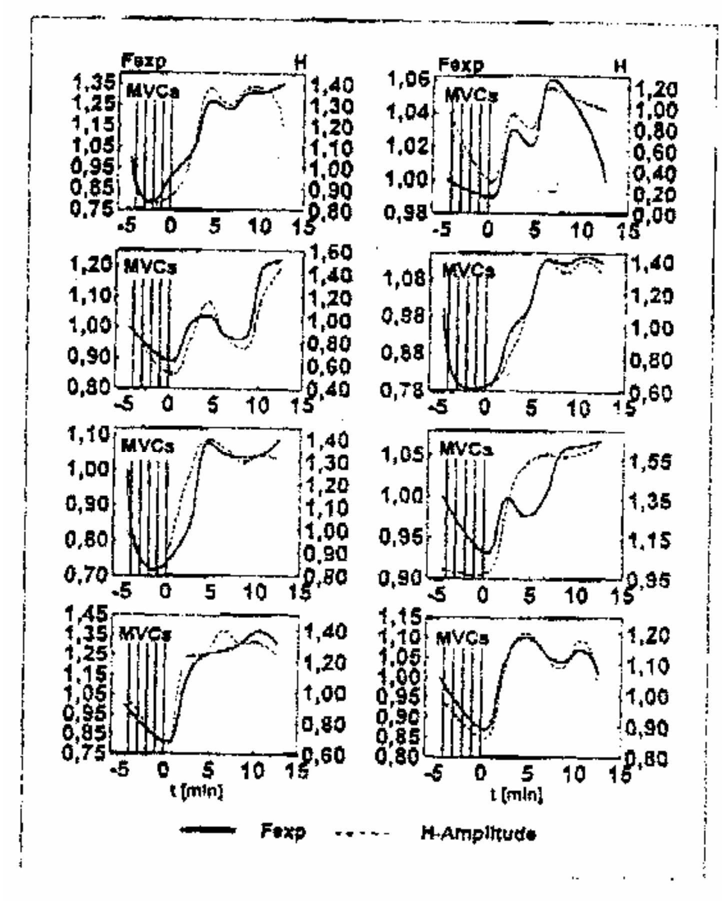

FIG 6: *Graphs of the explosive strength (solid line) and the H-reflex amplitude (broken line) in eight speed-strength athletes*

Conclusions for Practical Training and Competitions

The outlined results are responsible for significant consequences for training and competitions. The use of a few MVC's represents means to improve for a short term speed-strength performances and in particular the intensity of the force increases. The shorter is the available impulse duration, the larger is the significance factor for a speed-strength sporting performance. This effect is useable for several minutes. The H-reflex was in seven athletes observed over the normal duration in testing and indicated effects lasting for over 20 minutes.

It is of interest for practical training and competitions that a notable increase in explosive strength performances could only be achieved from maximal contractions (lifting of a 100% of a single repetition maximum or isometric MVC's). Sub-maximal contractions (3 x 90% of a single repetition maximum) failed to produce a similar effect on force increases. Similarly, no positive influence over several minutes could be achieved in speed-strength performances following the above approach (Gullich / Schmidtbleicher 1995).

This leads to the conclusion that the introduced PTP effects actually require maximal stimulus effects to produce noteworthy stimulus durations.

The use of maximal arbitrary contractions for improved explosive strength should, next to directly before competitions (warm-up), also be kept in mind for specific speed-strength training. It should be taken into consideration that the demand for maximal speed-strength performances will adapt better to the required speed-strength components following heightened neuro-muscular activation.

Next to a narrow common variation of the explosive strength with the stimulus of alpha motoneurons pools, an obviously high individual variability was observed in both characteristics. For this reason it is necessary to find the individual highest peak of PTP in order to benefit from the neuro-muscular activation in competitions and in training. This applies to short-term MVC's produced speed-strength performances, as well as for a "pure" training with maximal contractions.

Some basic experiments have indicated that even some stretching stimulations can influence a FTP effect (Hutton 1973). With this in mind, it appears advisable to give up stretching exercises between MVC's and speed-strength demands, as well as in training with MVC's.