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EFFECTIVENESS OF STIMULATION OF STRENGTH ABILITIES THROUGH A DIDACTIC PROGRAMME OF EXERCISE ON UNSTABLE SURFACES

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SUMMARY

In our work we sought to verify the effectiveness of a didactic programme of exercise on unstable surfaces for stimulation of strength abilities, compared to a similar didactic programme conducted on stable surfaces, thus creating an alternative choice for coaches, teachers, and sports instructors. A major element of the didactic process is the quality of the strength training programme on stable and unstable surfaces.

The sample of probands was selected from a population of college and recreational and active athletes from Prague. The group was made up of men aged 20 to 40 (n = 75). The probands were randomly assigned to three groups. From a methodological point of view, this was a single-factor, tri-level experiment. The experimental factor was represented by a specific strength programme (exercise on unstable surfaces, exercise on a stable base, without any exercise programme). The movement programme lasted 10 weeks and contained 22 exercise units.

When evaluating the overall results of the tests before and after the experimental programme, we come to be of the opinion that the experimental programme manifested itself positively in effectiveness of stimulating strength abilities. The strength programme had an influence on increasing the persistence of strength in dynamic and static regimens. In the case of a strengthening programme on unstable surfaces there was a tendency towards greater growth in the number of repetitions as opposed to programme on a stable base at the beginning of the programme in the case of exercise in a dynamic regimen.

Key words: effectiveness, strength preparation, unstable surfaces, deep stabilisation system

INTRODUCTION

Current sports practices place demands on all the elements of sports preparation, and constantly aim to increase training loads, especially in the area of intensification. For most sportsmen this requires a high level of preparation from the strength aspect as well.

Of the training means used for stimulating strength abilities, the most often used are exercise with free dumbbells, exercise on strengthening machines, and exercise with one's own weight as resistance (Petr, 2005). Recently, stimulation of strength abilities and activation of a deep stabilisation system using unstable surfaces has begun to assert itself. Kolář & Lewit (2005) and Potvin & Benson (2003) stress that unstable surfaces during exercise, as opposed to a stable base, lead to a heightening of the effectiveness of a deep stabilisation system (hereinafter, HSS), and also to greater concentration while carrying out the exercise. According to authors who deal with this issue (Ruiz & Richardson, 2005, Kyungmo et al., 2009, Potvin & Benson, 2003, Yanggie & Campbell, 2006), during strengthening exercises on unstable surfaces as opposed to a stable base, the muscles are engaged in activity at a different time and in a different order. When maintaining balance on unstable surfaces during strength exercises, receptors of movement organs – proprioceptors (Čierná et al., 2010) – are also engaged in the regulation of movement to a greater degree. Proprioceptors (muscle spindles, tendon bodies) constantly transmit information to the CNS about the current state of each muscle. Thanks to this, our movements are precisely directed in terms of extent and intensity, because constant centripetal impulses from these receptors allow steady control and modification of further muscle activity according to the immediate situation. Unstable surfaces are used most in the area of rehabilitation and physical therapy. Therefore, until now most scientific studies have been focused on the effect of exercise on unstable surfaces for rehabilitation purposes. Nevertheless, many athletes use this type of training as a supplement or a change of loading of already applied strength exercises.

Some authors (Ruiz & Richardson, 2005, Kyungmo et al., 2009, Yaggie & Campbell, 2006) point to the marked effect of using unstable surfaces on engagement of new motor units and posture musculature in the area of deep stabilisation of the torso system. According to Hamár & Lipková (1996), thanks to unstable surfaces muscle regulation also improves in production of muscle strength, which appears in the ability to engage a greater number of motor units in a certain time. Through coordination of the engagement of several motor units the maximum strength of contraction of an entire muscle, or entire muscle groups, is increased. Improved ability to concurrently activate a greater number of muscle fibres and motor units is monitored with the help of EMG (elektromyography), Fry and Associates (2004). The similar issue of activation of muscle groups during strength exercising on unstable and stable surfaces has been taken up by more authors (Goodman, 2008, Nuzzo, 2008), and they found that there was no difference in muscle activation when exercising with dumbbells on an unstable surface and on a bench. However, they also stated unambiguous conclusions of studies on the impact of strength training on unstable and stable surfaces. Based on these starting points, questions appear in the literature (and in sport practices) as to whether stimulation of strength abilities based on exercise on unstable surfaces brings greater effectiveness of development than similar exercises with fixed support of bodily segments.

According to these authors, strength exercises on unstable surfaces have relatively great potential. They can be a way to improve the quality of athletes' strength preparation, they can improve HSS function, and they can indirectly contribute to better athletic performance.

Goal of the work

To verify the effectiveness of a strength programme on unstable surfaces for stimulation of the strength abilities compared with a similar strength programme conducted on stable surfaces.

METHODS

Participants

The proband sample was selected from the population of college and Prague recreational and active sportsmen whose movement activity was not focused directly on stimulation of strength abilities. The sample was made up of men aged 20 to 40 (n = 75). The probands were randomly assigned to three groups (Experimental Group I, n = 25, Experimental Group II, n = 25, and Control Group III, n = 25).

Experiment design

From a methodological point of view, this was a single-factor, tri-level experiment. The experimental factor was represented by a specific strengthening programme (exercise on unstable surfaces, exercise on a stable base, without any exercise programme). The movement programme lasted 10 weeks and contained 22 exercise units (2–3 exercise units per week, each lasting 45 to 60 minutes).

Prior to the beginning of the programme, input measurements were carried out on levels of strength abilities, control measurements were made after five weeks, and output measurements followed completion of the programme.

Following random assignment into groups, experimental groups I and II conducted a test of maximum strength in order to determine the resistance for the interventional programme. The test included squats and bench presses. The loads during the strength programme were the same for all participants and ranged according to exercise type between 30% and 50% of the maximum. The tempos of the exercises were never maximal, and emphasis was placed on fluid movement in eccentric and concentric phases without stopping in the lowest or final positions. One repetition lasted 3 seconds for squats and 2.5 seconds for bench presses and push-ups (the repetition frequency was determined by a metronome). The maximum force test was carried out twice. The second was conducted after a control measurement. According to the results, the size of the weight for exercising was modified. The control group did not take the maximum strength test.

The first experimental group took the strength programme only on unstable surfaces.

The second experimental group completed the entire weight programme on stable surfaces with fixed body support segments. The control group completed no strength programme. The content of the experimental strength programme was the same or very similar in terms of exercises and devices used in the tests for both experimental groups: squats, bench presses, and push-ups in various modifications. In the programme both groups used the same number of repetitions and length of time at which the individual exercises were done.

PROCEDURES

The strength programme began and ended with diagnosis of strength abilities, in the form of six motor tests.

The beginning of the tests was preceded by standardised warm-ups. After five minutes of warming up on an ergonometer, the probands warmed up with five minutes of dynamic stretching and the subsequent performance of one series of squats and bench presses with barbells (20 kg), ten repetitions. After the warmup there was a three-minute rest period. By testing the probands we determined the values of 6 indicators of strength capability – squat with barbell (with 50% of the proband's weight), bench presses (with 40% of the proband's weight), and push-ups. The tests focused on demonstrating strength endurance in dynamic and static regimens. Strength performance for individual exercises was always conducted at vita maxima. Exercise in a dynamic regimen preceded a rest, followed by the same exercise, this time in a static regimen. The tempo of the individual repetitions in the dynamic regimen was set by a metronome. Between individual tests there was always a three-minute rest period.

Statistical analysis

Statistics were computed using the statistical software SPSS for Windows Version 19.0. The means and standard deviations were used to describe the scores of the three groups in all tests. The effect of the strength training was assessed by 3 × 3 repeated-measure ANOVA (training method × measurement) with measurement as a within-subject factor and training as a between-subject factor. Mauchly's test for sphericity was computed and the Greenhouse-Geisser epsilon was used to adjust the degrees of freedom. The equality of error variances was checked by Levene's test. The statistical significance of α-level was set to 0.05 and η^2 was used to assess the percentage of explained variance by the factor.

RESULTS

When evaluating the overall results of the tests before and after the experimental programme we come to the conclusion that our own experimental programme was manifested positively in the effectiveness of stimulation of strength abilities. The specific values of the tests for the individual research groups are stated further in Figures 1–6.

The means and standard deviations for all measurements in all tests are shown in Figures 1–6. We have found a significant interaction of strength program and measurement in all tests: repeated squats $p = 0.000$, $\eta^2 = 0.57$, squat hold $p = 0.000$, $\eta^2 = 0.22$, bench press $p = 0.000$, $\eta^2 = 0.46$, bench press hold $p = 0.000$, $\eta^2 = 0.27$, push-up $p = 0.000$, $\eta^2 = 0.27$, hold in push up $p = 0.000$, $\eta^2 = 0.18$. The larger percentage of explained variance is stated for dynamic tests.

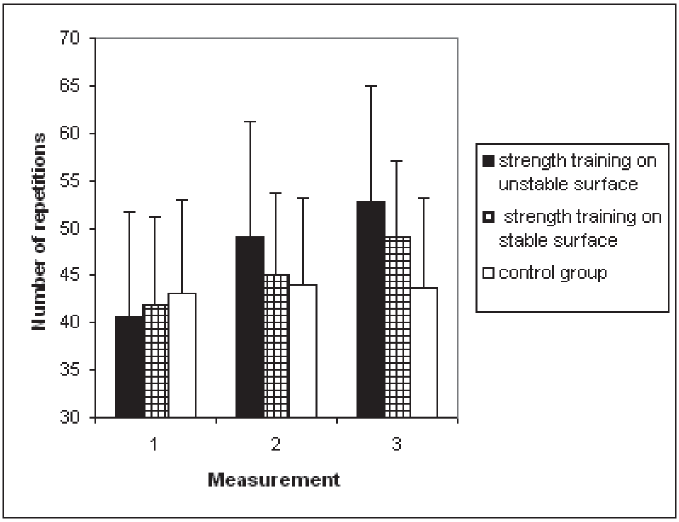

Figure 1. Average results and conclusive deviations for repeated squats in the 1st, 2nd, and 3rd measurements

In the Figure we can see that in the dynamic squat test during the programme, experimental group I (hereinafter, E I) improved an average 12.2 repetitions, experimental group II (hereinafter, E II) improved an average 7.2 repetitions, while the control group (KS) showed an average difference between the first and last tests of + 0.7 repetitions.

In the results of this test we can see the greatest increases in all the tested items.

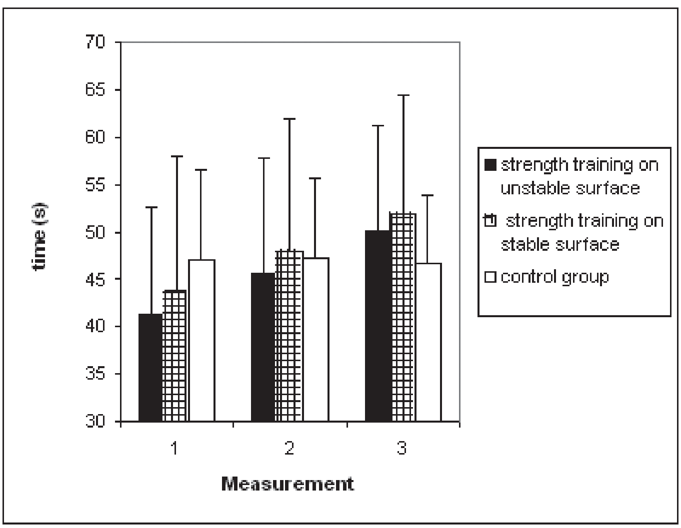

Figure 2. Average results and conclusive deviations for static hold in squats in the 1st, 2nd, and 3rd measurements

In the Figure we can see that in the static squat test during the programme EI improved an average 8.8 seconds, E II improved an average 8.3 seconds, while KS showed a difference between the first and last tests of – 0.4 seconds.

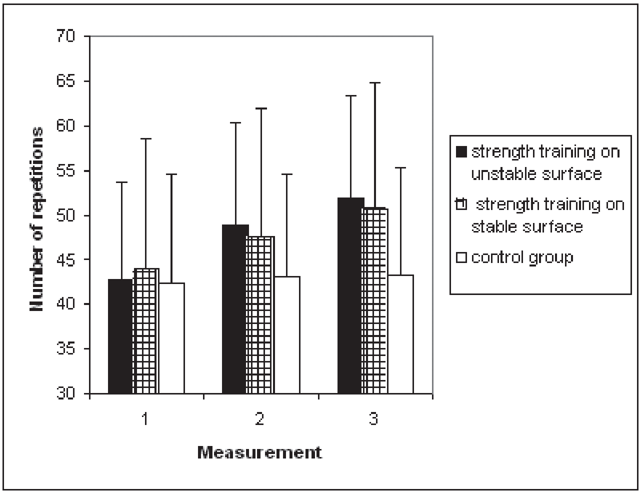

Figure 3. Average results and conclusive deviations for bench press repetitions in the 1st, 2nd, and 3rd measurements

In the Figure we can see that in the dynamic bench press test during the programme EI improved an average 9.2 repetitions, E II improved an average 6.8 repetitions, and KS showed a difference between the first and last tests of + 0.9 repetitions.

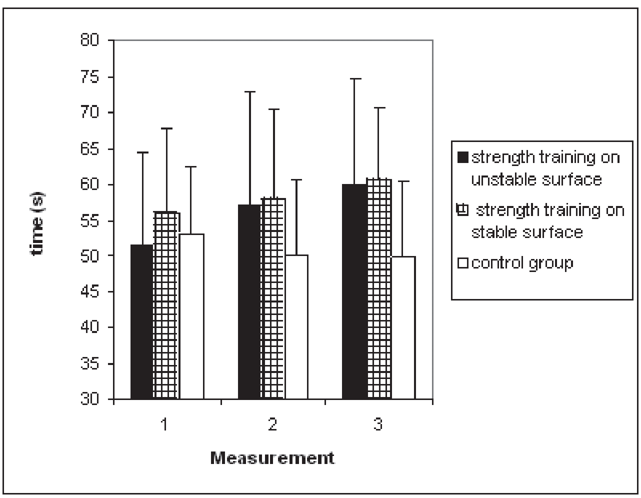

Figure 4. Average results and conclusive deviations for static hold in bench press in the 1st, 2nd, and 3rd measurements

In the Figure we can see that in the static bench press test during the programme EI improved an average 8.6 seconds, E II improved an average 4.8 seconds, and KS showed a difference between the first and last tests of – 3.5 seconds.

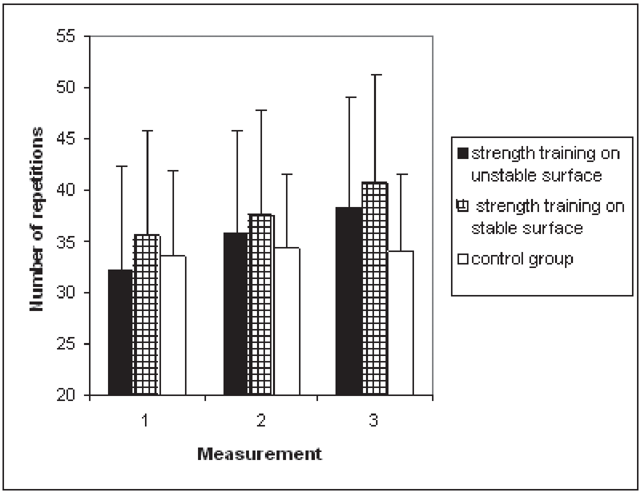

Figure 5. Average results and conclusive deviations for repeated push-ups in the 1st, 2nd, and 3rd measurements

In the Figure we can see that in the dynamic push-up test during the programme E I improved an average 6.3 repetitions, E II improved an average 5.3 repetitions, and KS showed a difference between the first and last values of + 0.4 repetitions.

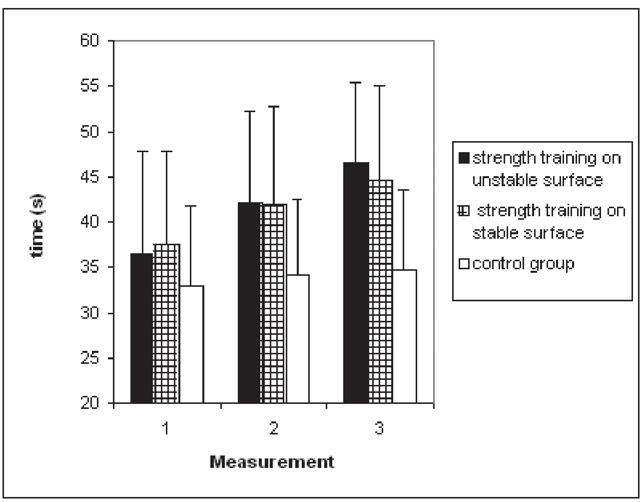

Figure 6. Average results and conclusive deviations for static hold in push-up in the 1st, 2nd, and 3rd measurements

In the Figure we can see that in the static push-up test during the programme E I improved an average 10.2 seconds, E II improved an average 7.1 seconds, and KS showed a difference between the first and last values of + 1.8 seconds.

From the results it is clear that the strength programme influenced an increase of measured values for both experimental groups. Their growth as opposed to the control group is also materially significant.

Figures 1, 3, 5 indicate a tendency towards greater increases with exercises in the dynamic regimen as compared with static repetitions (Figures 2, 4, 6).

For E I we stated that, unlike the case with E II, there is a tendency towards better results after the first five weeks of the strength programme, mainly in the dynamic squat tests (E I showed an average increase of 8.5 repetitions and E II showed an increase of 3.2 repetitions), dynamic bench presses (E I showed an average increase of 6.2 repetitions and E II 3.6 repetitions), and dynamic push-ups (E I showed an average increase of 3.6 repetitions, and E II 2.1, Figures 1, 2, 3).

DISCUSSION

The goal of the study was to verify the effectiveness of the strength programme on unstable surfaces for stimulation of strength abilities compared with a strength programme carried out on stable surfaces.

We noted marked differences between the experimental groups and the control group. The strength programme significantly affected the increase in measured values with both experimental groups. We agree with the literature, that a strength programme affects stimulation of strength abilities among recreational sportsmen as well, Fleck & Kraemer (1987), Baechle & Earle (2008).

For E I, we stated that, unlike E II, there was a tendency towards better results after the first five weeks of the strength programme. In comparison with publications by Ruiz & Richardson (2005), Kyungmo et al. (2009), Yaggie & Campbell (2006), Goodman (2008), and Čierná et al. (2010), the difference between groups E I and II is caused to the involvement of new motor units, i.e., marked intramuscular and intermuscular coordination. According to Kolář & Lewit (2005), the difference could also be result of heightened concentration on doing the exercises. Another question relating to our results involves energy expenditure. Some are of the opinion that when exercising on unstable surfaces the energy expenditure is greater. The results of E I could thus be partially affected by energy expenditure, and also with respect to the fact that our strength tests also specifically tested endurance. A study by Zemková (2010) deals with this issue. Zemková compared the energy expenditure of groups of exercisers on unstable and stable surfaces in squats and weight presses. Her results show that for one minute of exercise the energy expenditures were very similar. On an unstable surface energy expenditure was always, as opposed to energy expenditure on a stable surface, a bit greater. But this involved materially insignificant differences (27.5 kJ to 25.0 kJ in the squat and 22.1 kJ to 18.7 kJ in the weight press).

Also, according to Yaggie & Campbell (2006), Kolář & Lewit (2005), and Kyungmo et al. (2009), it could involve faster and higher-quality activation of the HSS in the area of the spine, which can be stimulated more markedly on unstable surfaces than on stable surfaces. In the second part of the experiment the differences between E I and E II are already minimal. With static exercising we note no differences between E I and E II. We may opine that the more marked strengthening effect for long-lasting strength training in the dynamic exercise regimen from the beginning of the programme is gradually lost after longer-lasting application, and exercising on unstable surfaces ceases to be effective. According to the results it appears that for a static exercise regimen, strength exercises on unstable surfaces as opposed to stable surfaces in terms of performance are practically insignificant.

Our finding is partially in accord with research by Čierná et al. (2010). She tracked changes in manifestations of maximum strength in the press on stable and unstable surfaces. She did not observe significant differences of maximum strength in 1 RM between a press on a bench and a press on a large ball. Tendencies towards greater performance were even manifested during the use of stable surfaces as opposed to unstable surfaces. In the bench press she measured values of 81.33 ± 12.74 kg as opposed to 80.67 ± 14.62 on a large ball.

We can apply the values we measured only to the population of men aged 20 to 40 who do not regularly engage in strength training. It would certainly be interesting to compare the results of the same or a similar experiment focused on strength duration (or even other strength manifestations) among high-performance or top-flight individuals with regular strength training. It was originally planned to also include in our experiment a group of first-rate competitors who engage in strength training regularly. But in the end, their strength training did not meet the conditions of our experiment, so it was not possible to include their results in this study.

CONCLUSION

Based on the results of our experiment, it was shown that the strength programme affected an increase in the duration of strength in both dynamic and static regimens. With the strength programme on unstable surfaces there was a tendency towards greater increases in the number of repetitions as opposed to the programme on stable surfaces at the beginning of the programme for exercise in a dynamic regimen. This can be applied in dynamic development as well as in a didactic process.

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ZVÝŠENÍ EFEKTIVITY STIMULACE SILOVÝCH SCHOPNOSTÍ PROSTŘEDNICTVÍM DIDAKTICKÉHO PROGRAMU CVIČENÍ NA NESTABILNÍCH PLOCHÁCH

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SOUHRN

V naší práci se zabýváme ověřením účinnosti didaktického programu cvičení na labilních plochách pro stimulaci silových schopností v porovnání s obdobným didaktickým programem realizovaným na stabilních plochách a vytváříme tak alternativní volbu pro trenéry, učitele a sportovní instruktory. Významným prvkem didaktického procesu je kvalita provedení silových cvičení na stabilní podložce i labilních plochách.
Vzorek probandů byl vybrán z populace vysokoškoláků a pražských rekreačních i aktivních sportovců. Soubor byl tvořen muži ve věku 20–40 let (n = 75). Probandi byli randomizovaně přiděleni do tří skupin. Z metodologického hlediska se jednalo o jednofaktorový tříhladinový experiment. Experimentální faktor představoval specifický silový program (cvičení na labilních plochách, cvičení na stabilní podložce, bez cvičebního programu). Pohybový program trval 10 týdnů a obsahoval 22 cvičebních jednotek.
Při posuzování celkových výsledků testů před a po experimentálním programu docházíme k názoru, že vlastní experimentální program se pozitivně projevil v efektivitě stimulace silových schopností. Silový program měl vliv na zvýšení vytrvalostní síly v dynamickém i statickém režimu. U silového programu na nestabilních plochách byla tendence vyššího přírůstku počtu opakování oproti intervenci na stabilní podložce v počátku programu u cvičení v dynamickém režimu, což je možné zohlednit jak ve sportovním tak i v didaktickém procesu.

Klíčová slova: efektivita, silová příprava, nestabilní plochy, hluboký stabilizační systém

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