60 - EFFECTS OF MECHANICAL VIBRATION EXPOSURE IN THE IMPROVEMENT OF THE RATE OF STRENGTH PRODUCTION

BRUNO PENA COUTO, HOSANNA RODRIGUES SILVA,
CAMILA MAIA MENEZES, LESZEK SZMUCHROWSKI
Laboratory of Load Evaluation, EEFFTO
CENESP / UFMG Belo Horizonte / MG / Brazil.
brunopena@yahoo.com.br

Introduction

It is known that the strength training causes adaptive response of neuromuscular functions (SALE, 1992) that happen due to the capacity of the skeletal muscle to modify in response to chronic exercises with overcharge (McDONAGH and DAVIES, 1984 and SZMUCHROWSKI, 1998). Among the adaptive responses of the muscle, the neural responses play an important role in the strength gains resulting from this type of training (SALE, 1992 and SCHMIDTBLEICHER, 1992), and are usually pointed out as principle responsible for the initial gains of strength, especially during the first four weeks of training (MORITANI and DEVRIES, 1980, HAKKINEN and KOMI, 1985). MANNARD and STEIN (1973) pointed two processes that interfere at the force generated by the muscle: cross bridges rate of actin and myosin and the process of slackness. The exercise with vibration exposure is a method of neuromuscular training that has been used both with athletes and as a treatment and way of prevention against such diseases as osteoporosis and the Parkinson disease (CARLSOO, 1982; RUBIN et al., 1998, RITTWEGER et al., 2000). The TORVINEN et al. study (2002) has shown that a vibration exposure during a period of 4 minutes (with frequencies of 25 to 40 Hz, and 2 mm of amplitude) didn't significantly change the strength to extend the knee in the case of young, healthy individuals. On the other side, there are many studies that suggest that vibration exposure interfere at strength improvement (BOSCO et al. 1999; RUNGE et al., 2000, BONGIOVANNI e HAGBARTH, 1990). Most of the researches used the whole body vibration (WBV) or vibrations perpendicular to the tendon. In this work we propose a new type of vibrations exposure. These studies don't make reference to the rate of strength production. Taking this under consideration, the aim of the present research was to compare the improvement of the rate of strength production, for elbow flexors, caused by an isometric strength training (maximal voluntary contraction - MVC) with isometric strength training with vibrations exposure in the direction of the torque produced by the muscle.

Method

Subjects

The sample included 19 students of the faculty of physical education, males, at the age of 24 3,28 years, not trained and that were not involved in strength trainings for superior members. As not trained individuals we considered those voluntaries that have never done a strength training or haven't done a strength training for the past year. We accepted volunteers that didn't present any type of bone, articular or muscular damage. All procedures were approved by the Ethical Committee for Researches at the Federal University of Minas Gerais and subjects provided informed written consent. None of the subjects smoked and no medication was being taken by them.

Calculation of rate of strength production

The rate of force production (TPF) was calculated by derivation of force-time curve, from the beginning of action to the time corresponding to maximal strength. The values of the strength have been obtained through a strength cell by *JBA, Zb Staniak*, Poland, connected to an amplifier of signals (WTM 005 2T/2P, *Jaroslaw Doliriski Systemy Mikroprocesorowe*, Poland). The amplifier itself has been connected to the computer with a *MAX* (version 5.1, *JBA, Zb Staniak*, Poland) interface that enables the analysis of the strength curve as a function of time (frequency of data input of 1000 Hz).

Application of mechanical vibrations

A special equipment® has been designed, that enables both isometric conventional training and the isometric training with vibrations applied in the direction of the muscular torque. The equipment is composed by an electromagnetic system controlled by the computer adapted to a *Scott* bench. The bench has been designed in a way that enables to adjust the height of the seat and the position of the superior members support. The electromagnetic system is formed by a reel (with a steel core) fed with continuous current. One of the extremities of the steel cable is fixed to the core of the reel and the other one is attached to a handle that serves as a grip for the hand. After the release of the electrical current a magnetic field is formed in the spirals of the reel. The field attracts the core of the reel and consequently the steel cable, applying the torque on the elbow (maximal strength on the reel 950N). When the current is interrupted after dislocating the steel cable (6 mm) the torque produced by the reel ceases. The control of the number of tractions to be executed by the reel is done through an interface with the use of a computer software (*software Time Trainer* 1.0®). It is possible to choose the duration of pulses and the quantity of electrical impulses emitted per minute, which is characterized by the frequency applied at the vibration. The strength cell has been connected approximately in the middle of the steel cable (lengthwise). In that way, when the steel cable is moved by traction (in the isometric training or in the training with vibrations exposure), this information is collected by the strength cell and forwarded to a different computer. The amplitude of the movement of the steel core of the reel can be limited by an adjustable screw with a precision of 1mm. The figure 1 illustrates the system used to collect data.

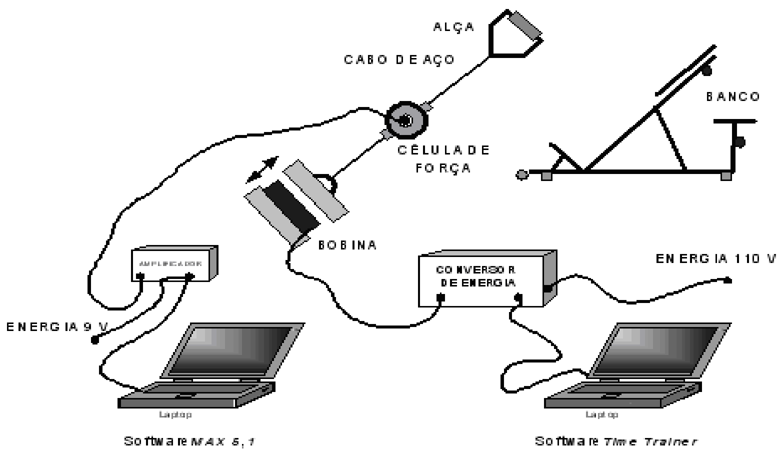

Figure 1 Illustrative scheme of the data collecting system.

Proceedings

Subjects have been divided into two groups: group 1 (conventional isometric training) and group 2 (isometric training with vibrations exposure). After the maximal isometric strength test (pre-test) the volunteers has been classified decreasingly, in the order of the maximal strength obtained by elbow flexors (from the 1st to the 19th). The volunteers with an impair number were classified to group 1 (n = 9) and the individuals with a pair number formed the group 2 (n=10). The experiment has been divided into 4 stages: knowing the equipment; pre-test; training; after-test. At the knowing the equipment stage, each volunteer executed 3 MVC's (3 repetitions with each superior member and an interval of 5 minutes between each repetition). The second stage of the experiment consisted in evaluating the initial maximal isometric strength of the elbow flexors. For that end, each volunteer executed 3 isometric maximal actions with each superior member, with duration of minimum 6s after having reached the maximal strength. There was a 5 minutes interval for recovery between each repetition. The best result for the maximal strength of each member has been chosen for comparison and the member that presented the smallest MVC has been chosen for the strength training. At the training stage each volunteer from both groups executed on a daily basis, one session composed out of 12 MVC's with elbow flexors, of a duration of 6 seconds, starting from moment when he reached the peak of the strength. There was an interval of 2 minutes for recovery between each repetition. Each volunteer executed the training 3 times a week with an interval of 48 hours for recovery between the training sessions. The training lasted for 4 weeks. The group 1 executed the conventional isometric strength training and group 2 an isometric strength training with vibrations exposure (frequency of 8 Hz and amplitude of 6mm). A single standard position has been determined for the execution of the pre-test, of the strength training and of the after-test. The volunteer was seated on the bench, with the axillary area leaned on the support (the glenoumeral joint bend at approximately 45 degrees). The member that was executing the muscular action with elbow flexors was placed against the support with the elbow bend at 90 degrees and the forearm tensed. The other member was kept with the elbow extended and radio-ulnar pronation, equally placed on the support. The figure 2 illustrates the standard position, as well as the equipment used during the experiment. The after-test consisted in a final evaluation of the maximal isometric strength of the flexors of the elbow. All proceedings of the pre-test were repeated. The pre-test has been done 72 hours after the last training session. The only feedback given to the volunteers during all stages of the experiment was the visualization of the strength curve as a function of time, simultaneously to its realization. For that end a computer screen was placed in front of the subject.

Statistical methods

In order to verify the normality of the data we used the Kolmogorov-Smirnov test. The comparison between the averages has been done with the use of the T-Student test. Besides the inferential statistics, a descriptive statistics of the data has been done. The level of significance adopted was 5% (= 0,05).

Table 1 – Rate of strength production (TPF) - Group 1 (isometric training).

Subject	TPF (N/s)	
	Pre-test	**After-test**
1	87,22	74,09
2	77,14	192,50
3	156,02	144,79
4	114,66	218,05
5	51,33	106,40
6	50,84	85,26
7	78,40	31,26
8	46,14	82,53
9	163,07	173,50
x	91,65	123,15
sd	44,08	62,29
C.V.	0,48	0,50

x = arithmetical average; sd = standard deviation; C.V. = variation coefficient. There was no significant difference between the pre -test and the after-test (p>0,05).

Table 2 – Rate of strength production (TPF) - Group 2 (isometric training with vibration exposure).

Subject	TPF (N/s)	
	Pre-test	**After-test**
1	110,01	128,48
2	24,55	82,32
3	67,89	64,27
4	119,11	175,75
5	174,44	138,43
6	102,43	212,66
7	153,90	154,56
8	65,83	84,28
9	103,04	149,10
10	95,20	92,26
x	101,64	128,21
sd	43,22	47,19
C.V.	0,43	0,37

x = arithmetical average; sd = standard deviation; C.V. = variation coefficient. There was no significant difference between the pre -test and the after-test (p>0,05).

Discussion

The main question discussed at this study is the verification of possible improvement of the rate of force production by application of mechanical vibration simultaneously an isometric training. There was no significant difference at the rate of strength production at both training methods used. As the rate of force production is related with the rate of cross bridges of actin and myosin (MANNARD e STEIN, 1973), we supposed that vibration exposure doesn't affect directly the process of rate of force generation. However, the fact that there still was no improvement of TPF at group trained with conventional isometric training suggest that maybe four weeks are not enough to provide such modifications, or that the training performed by subjects are not specific for promote the increase in the rate of force production.

Conclusion

The equipment designed for this research allowed the application of mechanical vibrations focused in a spot, in the direction of the torque produced by the muscle, contrarily to the application of vibrations normally described in literature. It is suggested that the isometric training with the addition of this type of vibrations had no direct influence on the development of the rate of force production, for flexors of the elbow, with the methods applied. We recommend another studies applying sub maximal isometric strength training and vibration exposure added to training of power.

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Correspondence address:
Bruno Pena Couto
Rua Pitangui, 3081. Bairro Sagrada Família Belo Horizonte / MG.
CEP. 31030-210.
Email: brunopena@yahoo.com.br

EFFECTS OF MECHANICAL VIBRATION EXPOSURE IN THE IMPROVEMENT OF THE RATE OF STRENGTH PRODUCTION

The effect of mechanical vibrations exposure in the development of muscular strength has been thoroughly studied by numerous scientists. Most of the studies point out the fact that mechanical vibrations cause what is called as “tonic vibration reflex” that helps increasing the muscular strength by influences of the mechanism of medullar reflexes. The aim of the present study was to check the influence of mechanical vibrations applied in the direction of the torque produced by the muscle in the improvement of rate of strength production, in flexor muscles of the elbow through comparison between a conventional isometric training and an isometric training with vibrations simultaneously added to the execution of the Maximal Voluntary Contraction (MVC). Nineteen volunteers, all males, at the age of 24 3,28 years, not trained, were divided into two strength training groups. The group 1 was supposed to execute an isometric training and group 2 an isometric training with mechanical vibrations exposure (frequency of 8 Hz and amplitude of 6 mm). Both groups executed 12 MVC's, duration of 6s each starting from the moment of peak of strength with intervals of 2 minutes between repetitions, 3 times a week during 4 weeks. The results showed that there was no significantly difference (p>0,05) between the group trained with addition of vibrations and the group trained isometrically when comparing improvement in the rate of strength production. It seems that vibration exposure does not interfere directly at the control of the rate of strength production.
Key words: vibrations, rate of strength production, strength training.

EFFET DE L'ENTRAÎNEMENT AVEC VIBRATION MÉCANIQUE SUR LE DÉVELOPPEMENT DU TAUX DE PRODUCTION DE FORCE

Plusieurs chercheurs ont étudié l'effet de vibrations mécaniques sur le développement de la force musculaire. La plupart des études signale que la vibration mécanique provoque ce qu'on a appelé le “réflexe tonique de vibration”, qui facilite l'augmentation de la force musculaire au moyen des influences sur les mécanismes des réflexes médulaires. Le but de notre étude était de vérifier l'influence de la vibration mécanique, appliquée dans la direction du moment de la force produit par le muscle, sur le taux de production de force dans les muscles fléchisseurs du coude, à l'aide de la comparaison entre l'effet causé par un entraînement isométrique conventionnel et un entraînement avec addition de vibration, simultanément à l'exécution de contractions volontaires maximales (CVM). Dix-neuf volontaires du genre masculin, à l'âge de 24 ± 3,28 ans, manquant d' entraînement, ont été distribués en deux groupes d'entraînement de force. Le groupe 1 a réalisé un entraînement isométrique et le groupe 2 a réalisé un entraînement isométrique avec addition de vibration mécanique (fréquence de 8 Hz et amplitude de 6mm). Les deux groupes ont réalisé 12 CVM en 6s à partir du pic de force, à un intervalle de 2 minutes entre les répétitions, 3 fois par semaine, pendant 4 semaines. Les résultats obtenus ont montré qu'il n'y a pas eu de différence significative entre le groupe entraîné avec addition de vibration et le groupe entraîné isométriquement (p>0,05). On suppose que l'entraînement avec addition de vibration n'intervient pas, au moins directement, dans les processus qui contrôlent le taux de production de force.
Mots-clés: vibration; taux de production de force; entraînement de force.

EFECTO DEL ENTRENAMIENTO CON VIBRACIÓN MECÁNICA EN EL AUMENTO DE LA TASA DE PRODUCCIÓN DE FUERZA

Varios investigadores están estudiando el efecto de las vibraciones en el desarrollo de la fuerza muscular. La mayoría de los estudios señala que la vibración mecánica provoca lo que fue llamado de “reflejo tónico a la vibración”, favoreciendo el aumento de la fuerza muscular a través de influencias en el mecanismo de los reflejos medulares. El objeto de ese estudio ha sido verificar la influencia de la vibración mecánica, aplicada hacia el torque producido por el músculo, en la tasa de producción de fuerza en músculos flexores del codo, a través de la comparación entre el efecto causado por un entrenamiento isométrico convencional y por un entrenamiento isométrico con adición de vibración simultáneamente a la ejecución de contracciones voluntarias máximas (MVCs). Diecinueve voluntarios del género masculino, con edad 24 3,28 años, desentrenados, fueron distribuidos en 2 grupos de entrenamiento de fuerza. El grupo 1 realizó un entrenamiento isométrico y el grupo 2 realizó un entrenamiento isométrico con adición de vibración mecánica (frecuencia de 8 Hz y amplitud de 6 mm). Ambos grupos realizaron 12 MVCs con duración de 6s a partir del pico de fuerza con intervalo de 2 minutos entre las repeticiones, tres veces a la semana, durante cuatro semanas. Los resultados obtenidos enseñaron que no hubo diferencia significativa entre el grupo entrenado con adición de vibración y el grupo entrenado isométricamente (p>0,05). Se supone que el entrenamiento con adición de vibración no interfiera, por lo menos directamente, en los procesos que controlan la tasa de producción de fuerza.

Palabras clave: vibración, tasa de producción de fuerza, entrenamiento de fuerza.

EFEITO DO TREINAMENTO COM VIBRAÇÃO MECÂNICA NO AUMENTO DA TAXA DE PRODUÇÃO DE FORÇA

Vários pesquisadores têm estudado o efeito de vibrações mecânicas no desenvolvimento da força muscular. A maioria dos estudos aponta que a vibração mecânica provoca o que foi chamado de “reflexo tônico à vibração”, favorecendo o aumento da força muscular através de influências no mecanismo dos reflexos medulares. O objetivo desse estudo foi verificar a influência da vibração mecânica, aplicada na direção do torque produzido pelo músculo, no taxa de produção de força em músculos flexores do cotovelo, através da comparação entre o efeito causado por um treinamento isométrico convencional e por um treinamento isométrico com adição de vibração simultaneamente à execução de contrações voluntárias máximas (MVCs). Dezenove voluntários do gênero masculino, com idade 24 3,28 anos, destreinados, foram distribuídos em 2 grupos de treinamento de força. O grupo 1 realizou um treinamento isométrico e o grupo 2 realizou um treinamento isométrico com adição de vibração mecânica (frequência de 8 Hz e amplitude de 6 mm). Ambos os grupos realizaram 12 MVCs com duração de 6s a partir do pico de força, com intervalo de 2 minutos entre as repetições, 3 vezes por semana, durante 4 semanas. Os resultados obtidos mostraram que não houve diferença significativa entre o grupo treinado com adição de vibração e o grupo treinado isometricamente (p>0,05). Supõe-se que o treinamento com adição de vibração não interfira, pelo menos diretamente, nos processos que controlam a taxa de produção de força.

Unitermos: vibração; taxa de produção de força; treinamento de força.