41° CONGRESSO NAZIONALE SIMFER

Roma, 13-16 ottobre 2013

EDIZIONI MINERVA MEDICA

Variations of muscle activity patterns in free weight *versus* flywheel resistance front squat: a pilot study

A. Baricich [1,2], M. Invernizzi [1], D. Susta [3], M. D'Innocenzio [1], D. Dameno [2], C. Cisari [1]

[1]Rehabilitation Department; Az. Ospedaliero Universitaria Maggiore della Carità, University of Eastern Piedmont "Amedeo Avogadro", Novara, Italy

[2]Novara Calcio Football Team, Novara, Italy

[3]School of Health and Human Performances, Dublin City University, Dublin, EIRE

Aim

Front squat is a classical resistance exercise, composed of concentric muscle contraction phase followed by an eccentric one. Due to its characteristics, the squat is often included in training programmes for athletes in different sports.[1]

In flywheel training, the resistive force is dynamic, proportional to the force generated by the subject; applying greater forces during exercise produces an increase in angular acceleration in the disc that subsequently produces an increase in resistive force. Moreover, the work produced during the concentric phase of the exercise is returned during the return phase, and it causes an increase in eccentric contraction of involved muscles.[2]

In front squat exercise, the use of different resistances (e.g. free weight or flywheel) could modify its execution.[3]

Our aim is to evaluate the variations of muscle activations during free weight versus flywheel resistance front squat.

Materials and methods

In our study we included young healthy subjects. Prior to data collection, all subjects had participated in a training program with practice sessions where they performed both free weight and flywheel front squats in order to assimilate the exercise correctly.

Following a brief warm-up, the subjects performed 3 sets of exercise: 1) free weight front squat with additional weight (20% of body weight, FW); 2) flywheel resistance (one disc, D1) front squat (Desmotec D.11, Biella, Italy); 3) flywheel resistance (2 discs, D2) front squat. The subjects performed 10 repetitions in each set. A rest period of 3 minutes was observed between sets. The set order was determined randomly.

During the repetitions, using surface Electromiography (sEMG) (PocketEMG, BTS, Milano, Italy) we registered the activity of following muscles: tibialis anterior (TA), soleus (SOL), gastrocnemius mediale (GAM), gluteus maximus (GM), erector spinae (ES), vastus medialis (VM), semitendinosus (ST); the registration was performed in both descending (eccentric) and rising (concentric) phases of the front squat. We analyzed muscle activation in one repetition, performed without errors during execution.

Assuming a non-Gaussian distribution, statistical significance was tested using Friedman test for repeated measures; when it was significant, post-hoc comparisons between FW, D1 and D2 were carried out using Dunn Test. The α level for significance for all analysed data was set at $P<0.05$

Results

8 healthy subjects (male n=5, female n=3) voluntarily participated in the study.

In concentric phase (rising), with respect to FW we observed an increased sEMG activity: TA 204.7% in D1 ($P<0.01$) and 196.5% in D2 ($P<0.01$); SOL 16.09% in D1 and 102% in D2 ($P<0.01$); GAM 44.3% in D1 and 77.7% in D2 ($P<0.05$); GM 41.7% in D1 and 177% in D2 ($P<0.01$); ES 2.7% in D1 e del 10.6% in D2; VM 40.4% in D1 and 67.1% in D2 ($P<0.05$); ST 9.1% in D1 and 37.9% in D2.

In eccentric phase (descending), with respect to FW we observed an increased sEMG activity: TA 14.8% in D1 and 15.3% in D2; SOL 120.3% in D1 ($P<0.05$) and 170.4% in D2 ($P<0.05$); GAM 84.5% in D1 ($P<0.05$) and 112.6% in D2 ($P<0.01$); GM 166.7% in D1 and 212.1% in D2 ($P<0.05$); VM 106% in D1 ($P<0.05$) and 131.4% in D2 ($P<0.01$); ST 36.9% in D1 and 49.5% in D2; we also observed a decreased sEMG activity in ES: 7.8% in D1 and 39.8% in D2 ($P<0.05$), respectively.

Results are reported in figure 1.

Discussion

Muscle stretch is a powerful stimulus promoting skeletal muscle growth [4] and there is a consensus on including eccentric exercises in resistance training protocols.[5-7] As previously stated, programs with eccentric or coupled eccentric-concentric exercises promote greater muscle hypertrophy than a concentric exercise alone.[5]

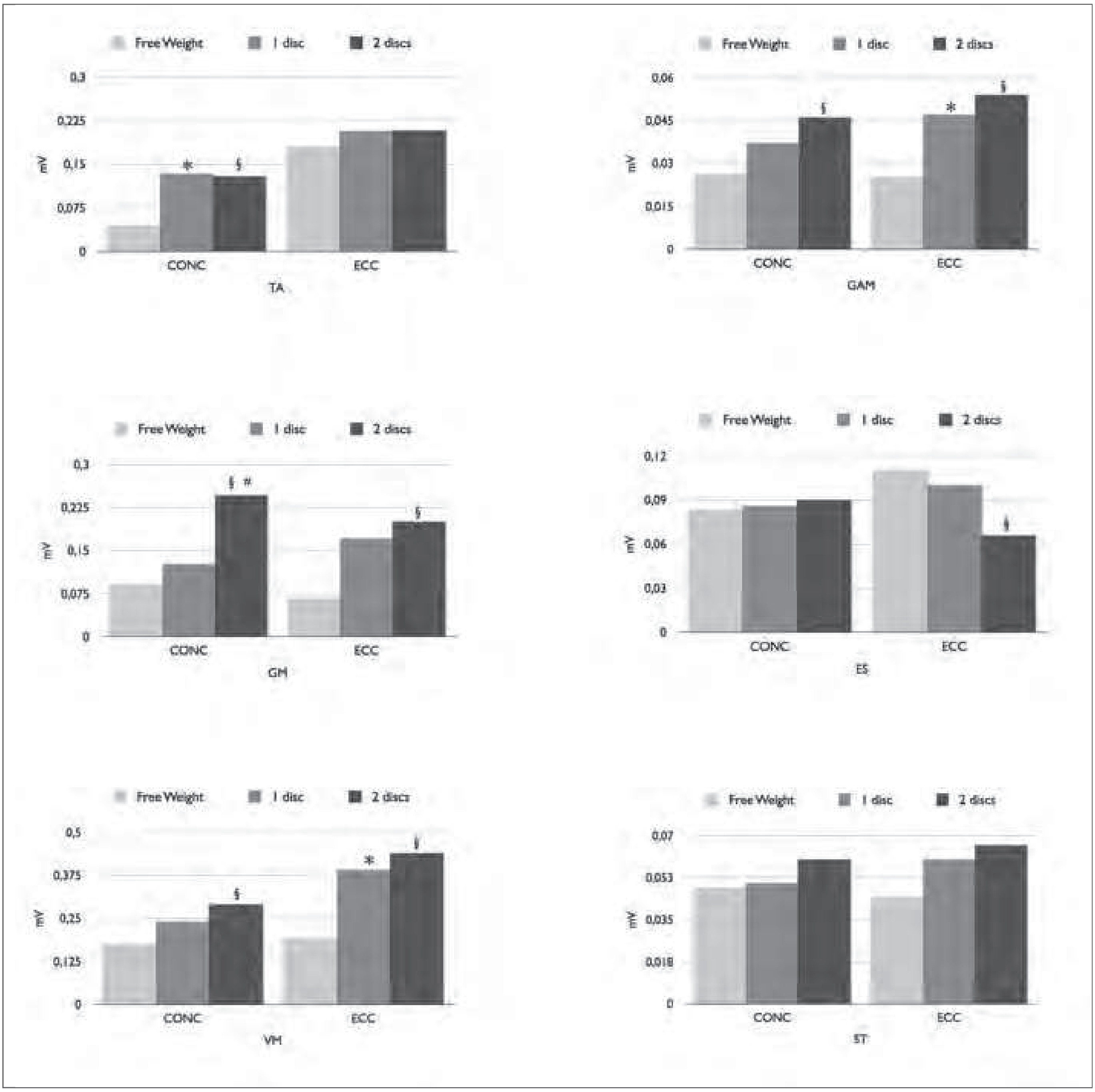

Figure 1. – sEMG variations during sets. [TA tibialis anterior; GAM gastrocnemius medialis; GM gluteus maximus; ES erector spinae; VM vastus medialis; ST semitendinosus; CONC concentric muscle contraction phase (rising), ECC eccentric muscle contraction phase (descending). *P<0.05 D1 versus free weight; §P<0.05 2 discs versus free weight; #P<0.05 2 discs versus 1 disc].

Furthermore, previous studies suggest more robust muscular adaptations following flywheel resistance exercise, supporting the idea that eccentric overload offers a potent stimuli which is essential to optimize the benefits of resistance exercise.[8, 9]

In our investigation, according to previous works, during flywheel front squat we registered a significant increase in eccentric sEMG activity, mainly in eccentric phase of front squat.

However, an interesting observation regards the ES activity in D1 and D2. In fact, a potential concern of flywheel resistance front squat is about exercise execution, with possible modifications of trunk position during exercise which could increase the overload risk on the spine. Our findings showed a reduced sEMG activity on ES suggesting the safety of flywheel front squat. Therefore, this could mean that this kind of exercise can be proposed even in rehabilitation settings or in early phases of training.

Further studies are required to analyze the kinetic anf kinematic variations of trunk and lower limb to point out this topic more accurately.

Conclusion

The flywheel front squat showed an increased muscular activity, mainly in eccentric phase of the exercise, in agreement with previous results.

The muscle activation pattern analysis did not show an increase in spine muscles activity, suggesting the absence of increased risk for spine overload; it could confirm the potential utility of flywheel resistance in resistance training even in rehabilitation settings and/or in early phases of training.

Further studies are required to evaluate the role of flywheel exercise in a rehabilitation program.

References

1. Clark DR, Lambert MI, Hunter AM. Muscle activation in the loaded free barbell squat: a brief review. J Strength Cond Res 2012;26:1169-78.
2. Alkner BA, Berg HE, Kozlovskaya I *et al.* Effects of strength training, using a gravity-independent exercise system, performed during 110 days of simulated space station confinement. Eur J Appl Physiol 2003;90:44-9.
3. Chiu LZ, Salem GJ. Comparison of joint kinetics during free weight and flywheel resistance exercise. J Strength Cond Res 2006;20:555-62.
4. Goldspink G. Changes in muscle mass and phenotype and the expression of autocrine and systemic growth factors by muscle in response to stretch and overload. J Anat 1999;194:323-34.
5. Hather BM, Tesch PA, Buchanan P *et al.* Influence of eccentric actions on skeletal muscle adaptations to resistance training. Acta Physiol Scand 1991;143:177-85.
6. Hortobagyi T, Devita P, Money J *et al.* Effects of standard and eccentric overload strength training in young women. Med Sci Sports Exerc 2001;33:1206-12.
7. Dudley GA, Tesch PA, Miller BJ *et al.* Importance of eccentric actions in performance adaptations to resistance training. Aviat Space Environ Med 1991;62:543-550.
8. Norrbrand L, Fluckey JD, Pozzo M *et al*. Resistance training using eccentric overload induces early adaptations in skeletal muscle size. Eur J Appl Physiol 2008 Feb;102:271-81.
9. Norrbrand L, Pozzo M, Tesch PA. Flywheel resistance training calls for greater eccentric muscle activation than weight training. Eur J Appl Physiol 2010;110:997-1005.