ISB 2013 BRAZIL

24th CONGRESS OF THE INTERNATIONAL SOCIETY OF BIOMECHANICS

SPEED EFFECT IN NET MUSCLE FORCE IN THREE PILATES METHOD HIP EXTENSION EXERCISES[1]

[1]Yumie Okuyama da Silva, [2] Débora Cantergi, [2] Artur Bonezi dos Santos, [2,3] Guilherme Aules Brodt, [2,3] Mônica de Oliveira Melo and [2] Jefferson Fagundes Loss
[1]Instituto Brasileiro de Gestão e Marketing, Recife, PE, Brazil
[2]Federal University of Rio Grande do Sul, Porto Alegre, RS, Brazil
[3]University of Caxias do Sul, Caxias do Sul, RS, Brazil
Email: yumie_okuyama@yahoo.com.br

SUMMARY
It has been proven important for instructors to understand how the behavior of external forces in Pilates exercises will affect the internal forces acting in the joint. The purpose of this study was to compare the net muscle force in Pilates exercises and to verify the influence of speed of execution in its performance. Twenty Pilates practitioners, performed three hip extension exercises being two situations in the Wall apparatus with the use of springs, and one in the barrel without springs. The different exercises of hip extension showed singular configurations that alter net muscle force of hip extensors. Also, changing the speed of execution influenced the internal forces.

INTRODUCTION
Nowadays, the Pilates method of exercise is presented in different lines, that may be generally grouped in traditional and modified lines [1,2]. Though the exercises are performed similarly, differences exist, such as the speed exercises are performed. The inertial effects that happen when performing free weight exercises are relatively known in literature. In a mechanical perspective, when a movement is performed in a slower manner, without big changes in speed, the load will be relatively the same in the entire movement [3,4]. However, most of the time acceleration is not constant, and because of it, the actual load of the exercise will be variable. This variation is larger the higher the acceleration. Nevertheless, when external load is originated from elastic materials, like springs, it is expected that spring length variation will be the sole factor changing the external load. In this case, angular velocities of up to 30º/s are low enough so the inertial effect from the segment's weight is insignificant [5]. Furthermore, the influence of different external loads in internal forces has not been studied. Hence, the aim of this study was to compare the net muscle force in three hip extensor Pilates exercises with and without the use of springs and to verify the influence of speed of execution in its performance.

METHODS
Twenty female Pilates practitioners volunteered for the study (34.5 ± 7.9 years old, 163.6 ± 4.8 cm, 57.27 ± 4.8 kg, 21.38 ± 1.31 kg/m^2 of BMI, 2.9 ± 2.1 years of Pilates experience). Participants were healthy without history of hip musculoskeletal injury. They performed the hip extension in three situations, being two situations in the Wall apparatus with the use of springs (spring fixed at a higher position and spring fixed at a lower position), and one in the barrel without springs. Exercises in the Wall started with 90 degrees of hip flexion and the exercise in the barrel started with 45 degrees of flexion. Regardless of the exercise, subjects were asked to extend their legs until zero degrees of flexion during the exercise.

Two series of 7 repetitions were performed for each exercise in two distinct speeds: preferred speed (as the participant performs during regular Pilates training) and faster speed (the higher speed the participant could do without modifying the movement's ideal posture). During data collection, one Pilates experienced trainer instructed the participants in order to help maintaining the correct movement. The series were performed in random order of each apparatus, and the preferred speed was always performed first. Three minutes interval was kept between them.

Reflexive markers were positioned at the acromion, anterior superior iliac spine, anterior posterior iliac spine, greater trochanter, fibular head, lateral malleolus, fifth metatarsal and calcaneus. Also, two markers were positioned in the spring. Kinematic variable were obtained using one video camera (50 Hz) on the sagittal plane to the subject and data were digitized using software Dvideow (Digital Video For Biomechanics – Windows32 Bits) [6]. Kinetic data was obtained from the exercises in Wall with two 200N load cell (Alfa instruments –model S-200), attached between each spring and the apparatus.

Data was filtered using Winter's residual analysis. Anthropometrics tables were used for segment weight, center of mass and inertial moment [7]. Hip joint net moment and forces were calculated using inverse dynamics analysis, considering the leg, pelvis and trunk as rigid segments, where trunk and pelvis were considered stationary [7]. Muscles weighted average perpendicular distance was obtained in order to find the net muscle force [8]. Net muscle forces were calculated for every 10 degrees of the range of motion. The net muscle force integer, normalized by body weight (BW), was used for the comparison between speeds.
After data normality was tested, One Way Anova was used to compare net muscle force integrate between speeds for

each exercise. Also, another One Way Anova was used for comparison of the net muscle force between exercises. Post hocs of Bonferroni and Tahmane were used. Significance level adopted for all tests was $\alpha \leq 0.05$.

RESULTS AND DISCUSSION

Differences were found in the net muscle force between exercises in the angles of 0, 10, 20, 30 and 40 degrees in the usual speed (Figure 01). Mean usual speeds were 16.6 ± 6.1°/s, 15.3 ± 6.4 °/s and 9.3 ± 4.3°/s for lower spring, higher spring, and barrel, respectively, while fast speeds were 26.9 ± 10.7 °/s, 26.1 ± 9.6 °/s and 18.3 ± 8.1 °/s. There was difference between speeds for the movement performed in the Wall with the lower spring, where the higher the speed, the slowest net muscle forces, ($p \leq 0.001$) and for the movement performed in the barrel without spring, higher the speed, the higher net muscle forces ($p \leq 0.001$). No difference was found between speed in the Wall with the higher spring ($p=0.811$).

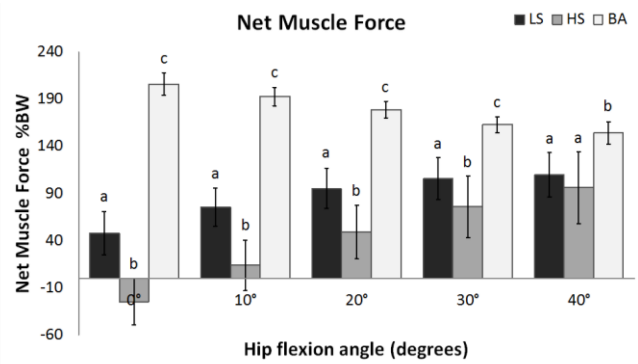

Figure 1: Net muscle force between exercises between 0º and 40º in usual speed. Different letters represent significant difference between exercises in the same angle. Negative forces represent the use of flexor muscles.

The influence of the spring's line of action has been shown previously to influence the external demands and, consequently, the strategy of the involved muscles [3]. During hip extension exercises performed in the Wall, there will be an influence of spring position (high or low), which will be determinant for the characteristics of the exercise [3] and the magnitude of the net muscle forces (Figure 01).

When the exercise is performed in the barrel, there is a difference regarding the moment of the segment's weight. While in the Wall the leg force is directed towards hip extension, aiding the movement, in the barrel it is the leg weight that will act as load for the exercise, since the force is directed towards the hip flexion. This also changes the magnitude of the load. In both cases, the highest load of the legs will happen when it is in a horizontal position, corresponding to 0 degrees of hip flexion. In the Wall, this will be the point where the leg weight helps the most and less net muscle force at the joint is needed, while in the barrel it is the moment it presents the highest external load, and the highest net muscle forces at the joint occur.

Flow is one of the six principles of the Pilates method. Exercises should be performed smoothly, without jerky movements, not too slow and not too fast [1]. However, how fast or slow an exercise should be performed has not been established and each of the method's lines define its on criteria. It has been shown that a movement usually performed in a determined speed will present a changes muscle recruitment pattern when it is performed in different speeds [9,10,11]. In strength training the speed exercises performance are directly related to the type of training targeted. Slow speed is used when muscle resistance is aimed, and faster speed is needed for motor recruitment when force and potency are being trained [10].

Since external loads in Pilates are originated from springs, the inertial effects during an exercise are only dependent on the segments being moved which does not suffer inertial effects. Hence, movements performed in low constant speed will not suffer inertial effects [3,4]. Angular velocities of up to 30º/s are considered slow enough in order to have an insignificant inertial effect[6]. This was the case for all exercises performed in usual speed in the present study. Still, there were important speed's effects correlated to the net muscle force at the hip in the situations studied. At slower speeds, the controlled movement does not generate high accelerations, and in higher speeds the acceleration effect is influenced by the net muscle force during the hip extension exercise studied.

These results may be applied to clinical situations, where different pathologies or muscle strengthening may be indicated [12]. Thus, when constant net muscle force is expected during hip extensions, the higher speed is indicated. For lower net muscle force, lower springs in fastest speeds, and for the highest muscle demand, leg extension at the barrel in higher speed.

CONCLUSIONS

When hip extension is performed in the Wall with the lower spring, the net muscle force decreased as speed increased. When the exercise was performed using the barrel, the net muscle force increases as the speed increased. When the exercise was performed in the Wall with the higher spring, the net muscle force did not change regardless of the speed.

REFERENCES

1. Owsley A. *Athletic Therapy Today*. **10**(4):19-25, 2005.
2. Latey P. The Pilates method: History and philosophy. *Journal of Bodywork and Movement Therapies*. **5**(4):275-282, 2001.
3. Silva YO, et al., *Revista Brasileira de Fisioterapia*. **13**(1):82-88, 2009.
4. Melo MO, et al., *Revista Brasileira de Fisioterapia*. **15**(1):23-30, 2011.
5. Loss JF and Candotti CT. *Revista Brasileira de Fisioterapia*. **12**(6):502-10, 2008.
6. Barros RML, et al., *Revista Brasileira de Engenharia Biomédica*. **15**(1-2):79-86, 1999.
7. Winter D. *Biomechanics and Motor Control of Human Movement*. New York, Wiley, 2005.
8. De Toledo JM, et al., *Journal of Applied Biomechanics*. **24**(1):51-57, 2008.
9. Germain P, et al., *Science and Sports*. **11**:39-45, 1996.
10. Hatfield DL, et al., *Journal of Strength and Conditioning Research*. **20**(4):760-766, 2006.
11. Bottaro M, et al., *European Journal of Applied Physiology*. **99**(3):257-264, 2007.
12. Loss JF, et al., *Revista Brasileira de Fisioterapia*, **14**(6):510-517, 2010.