



Original

## Surface electromyography comparison of the abdominal hypopressive gymnastics against the prone bridge exercise



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### ABSTRACT

**Objectives:** Abdominal hypopressive gymnastics (AHG) is a little-researched method designed to train the muscles of the abdominal wall and pelvic floor under low stress. This study's objective is to compare levels of muscle activation in AHG against prone bridge by surface electromyography (sEMG) of the abdominal wall muscles.

**Methods:** Twenty healthy subjects were enrolled to measure the muscle activity of the rectus abdominis (RA), transversus abdominis/internal oblique (Tra/IO), and external oblique (EO) during three exercises: prone bridge (PB), orthostatic hypopressive (OH), and hypopressive bridge (HB). Root mean square values normalized to the PB (%PB) as a baseline were used to compare the PB against OH and HB.

**Results:** The median PB ratio (%PB) for the Tra/IO showed -10.31% and +59.7% activation during OH and the HB, respectively, whereas the RA showed -77.8% and +19.3% and the EO -39.8% and +9.8%. Significant differences were found for all muscles except the Tra/IO during the OH.

**Conclusion:** This study's results suggest that hypopressive exercises facilitate the activation of the Tra/IO similar to bridge exercises while simultaneously reducing RA and EO activity. This suggests that hypopressive training is a valid alternative for activating the abdominal muscles, isolating the Tra/IO at low intra-abdominal pressure.

**Keywords:** Electromyography, Abdominal wall, Gymnastics, Pelvic Floor, Abdominal Oblique Muscles, Exercise therapy, Exercise, Rectus Abdominis, Healthy volunteers.

## Comparación de la electromiografía de superficie de la gimnasia abdominal hipopresiva con el ejercicio de puente prono

### RESUMEN

**Objetivos:** La gimnasia abdominal hipopresiva (AHG) es un método poco estudiado, diseñado para entrenar los músculos de la pared abdominal y piso pélvico con bajos niveles de estrés. Los objetivos de este estudio fueron comparar los niveles de activación muscular de la AHG y el ejercicio de puente en prono a través de electromiografía de superficie (sEMG).

**Métodos:** 20 voluntarios sanos fueron reclutados para medir el recto abdominal (RA), transverso del abdomen/oblicuo interno (Tra/IO), y oblicuo externo (EO) durante tres ejercicios: Puente en prono (PB), hipopresivo Ortostático (OH) y Puente hipopresivo (HB). La raíz media cuadrática normalizada en proporción al PB (%PB) como línea de base fue utilizada para la comparación.

**Resultados:** El %PB para el Tra/IO fue de -10.31% y +59.7% durante el OH y HB respectivamente, el RA -77.8% y 19.3% y el EO -39.88% y +9.8%. Todos presentaron diferencias significativas, excepto el Tra/IO durante el OH.

**Conclusión:** Los resultados sugieren que el ejercicio hipopresivo facilita la activación del Tra/IO de manera similar al ejercicio de puente mientras que simultáneamente se reducen la actividad del RA y el EO. La AHG es una alternativa válida para activar la musculatura abdominal, aislando al Tra/IO a baja presión intraabdominal.

**Palabras Clave:** Electromiografía, Pared Abdominal, Gimnasia, Suelo pélvico, Oblicuo abdominal, Músculos, Ejercicio terapéutico, Recto Abdominal, Voluntarios sanos.

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## Comparação da eletromiografia de superfície da ginástica abdominal hipopressiva com o exercício em ponte

### RESUMO

**Objetivos:** A ginástica abdominal hipopressiva (AHG) é um método pouco estudado, projetado para treinar os músculos da parede abdominal e do assoalho pélvico com baixos níveis de estresse. Os objetivos deste estudo foram comparar os níveis de ativação muscular do AHG e do exercício em ponte através da eletromiografia de superfície (EMGs).

**Métodos:** 20 voluntários saudáveis foram recrutados para medir o rectus abdominis externo (RA), transverso abdominal/oblíquo interno (Tra/IO) e oblíquo (EO) durante três anos: Ponte (PB), Hipopressiva ortostática (OH) e ponte hipopressora (HB). A raiz média quadrática normalizada em proporção ao PB (% PB) como base foi utilizada para a comparação.

**Resultados:** %PB para o Tra/IO foi de -10,31% e + 59,7% durante o OH e HB, respectivamente, o RA -77,8% e 19,3% e o EO -39,88% e + 9,8%. Todos apresentaram diferenças significativas, exceto o Tra/IO durante o OH.

**Conclusão:** Os resultados sugerem que o exercício hipopressivo facilita a ativação de Tra/OI de forma semelhante ao exercício em ponte e simultaneamente reduz a atividade de RA e OE. O AHG é uma alternativa válida para ativar os músculos abdominais, isolando o Tra/IO a baixa pressão intra-abdominal.

**Palavras-chave:** Eletromiografia, Parede Abdominal, Ginástica, Chão pélvico, Abdominal abdominal, Músculos, Exercício terapêutico, Reto abdominal, Voluntários saudáveis.

### Introduction

Abdominal hypopressive gymnastics (AHG) can be defined as a set of postural techniques that synergistically activate the muscles from the pelvic floor and abdomen in response to negative intra-abdominal pressure (IAP).<sup>1</sup> AHG have been used traditionally for the enhancement of pre- and postpartum urinary and fecal incontinence, genital prolapse, and other gynecological disorders related to the function of the pelvic floor and abdominal muscles.<sup>2,3</sup> Other applications of the AHG include the treatment of back pain and gym activities to train the core muscles.<sup>1,4,5</sup>

The search for an ideal exercise to reinforce the abdominal wall at high activation levels under favorable and safe conditions for the lumbar spine and pelvic diaphragm has encouraged the development of several approaches.<sup>6-8</sup> One of the arguments for studying AHG is that it could be a valid training method for the deep abdominal muscles, this could have repercussions in core stability and rehabilitation programs.<sup>8,16-20</sup>

AHG focus on pelvic floor and abdominal wall activation<sup>1,3</sup> but few studies have compared this training against other abdominal exercises through surface electromyography (sEMG) and most of them have focused on evaluating their effects on the pelvic floor.<sup>1,3,11</sup>

Therefore, the present study aimed to investigate how AHG perform against the prone bridge (PB) to determine if they produce higher sEMG signal amplitudes, which are assumed to yield greater strengthening effects.<sup>3,4,12</sup> We hypothesized that AHG will perform better or similarly to the bridge exercise for transversus abdominis/internal oblique (Tra/IO) and external oblique (EO).

### Methods

#### Participants

A database was generated with volunteers from the university campus who were recruited via newsletters, after which a random selection was applied. A total of 20 right-handed participants, 10 healthy men and 10 healthy women, with an average age of  $21.8 \pm 1.5$  years and body mass index of  $22.8 \pm 1.2$ , who met the inclusion/exclusion criteria were finally considered for the study. Patients with a history of lumbar pain, pregnancy, spine surgery, or skeletal muscle injuries that caused a physical disability or limitation were excluded. None of the subjects practiced or had practiced any sport in a competitive way during the last three years. Participants were also asked to abstain from physical strain 48 hours prior to the evaluation and sign and approve the study's

informed consent. All procedures were approved by the university's ethical board and were conducted based on the Declaration of Helsinki.

#### Procedures

Data of electromyography were recorded with a Trigno wireless sEMG sensor system (Delsys, Boston, MA, USA). Trigno electrodes included four 5-  $\times$  1-mm skin sensors with 1-cm spacing between sensors. EMG data were acquired with EMGWorks 4.1.7 software (Delsys, Boston) at a frequency rate of 1926 Hz. Before placing the electrodes, the skin was prepared, shaved, and sanitized with cotton and alcohol. The electrodes were attached to the abdomen with double-sided tape and reinforced with Transpore plastic tape.

Simultaneous sEMG readings were taken for the rectus abdominis (RA), Tra/IO (since it is impossible to rule out the internal oblique muscle overlapping with the transversus abdominis muscle with the sEMG),<sup>8,13</sup> and EO muscles, all from the subject body's right side.

Electrodes were placed for the RA, 5 cm below and 3 cm lateral to the xiphoid process; Tra/IO, 2 cm medial and caudal to the anterior superior iliac spine; and EO, just under the eighth rib's anterior angle, superolateral to the upper lateral costal margin.<sup>12</sup> Signal quality was monitored at all times during the tests to ensure low noise and interference levels.

Subjects were summoned two days before the evaluation to be briefed on the exercises to be performed and ensure a proper execution during the evaluation period. Participants performed two repetitions of each exercise, with a 1-minute resting period between repetitions and 4-minute intervals between exercise sets. The arithmetical means of each exercise's two repetitions for each of the three evaluated muscles, was calculated.

To establish a valid reference for comparison, the PB was used because previous studies reported the highest activation of the abdominal muscle wall in this exercise.<sup>12</sup> The results shown in this study are expressed using the PB performance as baseline, which means that 0% is an activation equal than the PB performance; hence, positive values show higher percentage yield and vice versa.

Prone Bridge: the participant was asked to remain in the PB position, maintaining a neutral position of the hips, pelvis, and lumbar spine joints. Feet were placed in such a manner that they matched the hip's width, the forearms acted as support, elbows were flexed under the glenohumeral joints, and arms leaned perpendicular to the surface. Participants held that position for 25 seconds.

**Orthostatic Hypopressive (OH):** All volunteers received AHG training one week before the data collection. The subjects were instructed to start the exercise with costal breathing and raising the lower ribs, followed by total expiration. They were then asked to perform expiratory apnea and, with the glottis closed, expanded and raised their rib cage by contracting accessory inspiratory muscles while standing in an upright position with knees, elbows, and shoulders slightly flexed.<sup>1</sup>

**Hypopressive Bridge (HB):** The subject assumed the same PB exercise position while performing the HB exercise.

Figure 1 shows a participant performing the PB, OH, HB exercises.



**Figure 1.** Orthostatic Hypopressive (OH), Prone Bridge (PB) and Hypopressive Bridge (HB) exercises.

**Data Processing:** raw electromyography signals obtained from each muscle were band-pass filtered at 10 to 400 Hz and analyzed with the EMGworks software (Delsys). Next, the root mean square

(RMS) was calculated for the signal and was processed every 125 milliseconds. The RA, EO, and Tra/IO average EMG activity was acquired between the two repetitions performed by each subject during the three different exercises in a 10-second window. Lastly, the RMS data for each subject were normalized and expressed as the ratio (%) of the PB for comparison analysis purposes.

**Statistical Analysis**

The Kolmogorov-Smirnov test was applied to determine if the variables exhibited normal distribution. Because of variable nonnormal distribution, the Wilcoxon test to identify specific differences was used with a 95% significance level in all the tests and the median and interquartile range is presented. Statistical analyses were carried out using Statistical Package for Social Sciences (SPSS) software and GraphPad Prism 6 software version 18.

**Results**

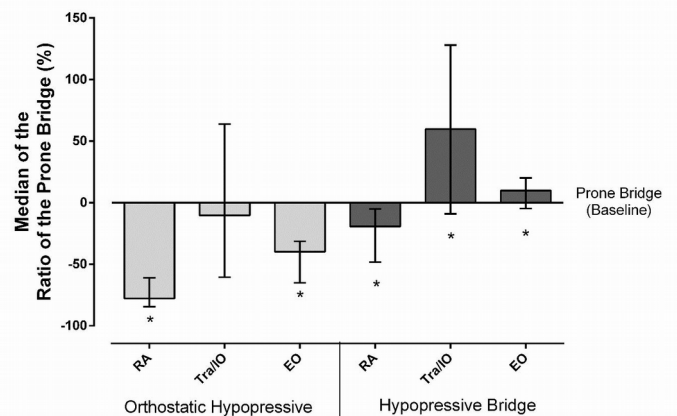
The median performance of the OH was lower than the PB for the RA (-77.84% [-84, -61]) and EO (-39.88% [-65, -31]) with statistically significant differences; the Tra/IO showed high variability (median, 10.31% [-60, 63]) and no statistically significant differences against the PB ( $p = 0.97$ ). The HB showed a better performance than the other exercises; only the RA performed worse than the PB (-19.33% [-48, -5]). The Tra/IO increased its ratio (59.79% [-9, 128]), and the EO showed minimal differences (-9.8% [-5, 20]). No statistical differences were found between men and women.

**Table 1.** Z-test values for Wilcoxon's post hoc test for the difference between the values of normalized electromyographic activity between the rectus abdominis, external oblique and transversus abdominis/internal oblique ratio muscles in each position analyzed.

RA	HB	vs	OH	-3.808	0.000
	PB	vs	OH	-3.771	0.000
	PB	vs	HB	-2.688	0.007
Tra/IO	HB	vs	PB	-2.277	0.023
	PB	vs	OH	-0.037	0.970
	PB	vs	HB	-2.987	0.003
EO	HB	vs	OH	-3.883	0.000
	PB	vs	OH	-3.734	0.000
	PB	vs	HB	-2.203	0.028

RA: rectus abdominis; Tra/IO: transversus abdominis/internal oblique; EO: external. Statistically significant differences were found for all the muscles except for the transversus abdominis/internal oblique Tra/IO between the prone bridge and orthostatic. oblique.

Figure 2 shows the median and IQ25-75 range for the ratio activation percentage of the prone bridge exercise for the rectus abdominis, transversus abdominis/internal oblique and external oblique muscles during the orthostatic hypopressive and the hypopressive bridge.



**Figure 2.** Prone bridge ratio (%PB). RA: rectus abdominis; Tra/IO: transversus abdominis/internal oblique; EO: external oblique; OH: orthostatic hypopressive; HB: hypopressive bridge; \*:  $P \leq 0.05$ ; \*\*:  $P \leq 0.01$ ; \*\*\*:  $P \leq 0.001$ .

## Discussion

This study shows that the hypopressive technique facilitates Tra/IO activation, similar to bridge exercises inducing reduction of the RA activity. As this study and others suggest, the behavior of the abdominal muscles during AHG is also affected by body position.<sup>1</sup>

We hypothesized that AHG would perform better than or similar to bridge exercise for Tra/IO and EO, but only Tra/IO performed similar to the PB. These findings contribute to the scarce existing knowledge on the behavior of the abdominal hypopressive technique compared with traditional exercises.<sup>2,3,11</sup> Most of the studies published in the field of AHG focused on determining whether they produce low abdominal stress levels and the clinical effects on pelvic floor dysfunctions with mixed results.<sup>1-3,7,11,14,15</sup>

Although other research has mentioned that it is possible to isolate the Tra/IO activity by applying the abdominal hollowing technique,<sup>13,16</sup> the AHG shows significant execution differences since major diaphragm elevation and abdominal volume reduction are required.<sup>14</sup>

Because of the difficulties in the control of the diaphragm during the execution of the hypopressive exercises, part of the population did not execute it in the standardized manner, also Variability in the Tra/IO may be due to differences in the contraction intensity between subjects. This difficulty was observed during the OH and HB exercises; hence, a high variability in Tra/IO contraction levels can be observed in the study's data. We also found an interesting high performance with statistically significant difference for the Tra/IO in the HB. The study results showed that Tra/IO activity levels were enhanced during the execution of the HB compared with the PB. The latter results can become relevant if we take into account that this exercise (PB) is reported to have one of the highest levels of abdominal activity, especially for the Tra/IO and EO.<sup>12,16,19,21,22</sup> This argument is important to consider AHG as an effective technique for Tra/IO training and leads us to think that the HB could be one of the most demanding static exercises reported for this muscle.

The reduction in IAP resulting from the hypopressive exercises could be compensated to some level by higher activity of the spine and abdominal stabilizing muscles to avoid shear stress and uncoordinated movement at the joint level due to the loss of support from the abdominal cavity.<sup>6,20,23</sup> The latter could explain higher the Tra/IO and EO activity during HB exercises.

It also has been reported that there is a decreased activity of the RA during the bipedal position<sup>5</sup> and that a motor inhibitory synergy between the diaphragm and the RA could be related to the reduction of the abdominal perimeter due to diaphragm elevation and relaxation.<sup>5,13</sup> This is supported by our research that shows decreased activity for the RA compared with the Tra/IO and OE during orthostatic hypopressive. This finding seems to be more frequently interpreted by other authors as an isolated and selective Tra/IO contraction during AHG and hollowing.<sup>6,13,23-25</sup>

Although it is currently not possible to establish that the HB behaves as a safer spine exercise than the PB, this exercise could combine low stress levels with higher activity for the Tra/IO and EO than the traditional PB and could be considered as an effective and selective training approach for these muscles.<sup>6</sup>

Comparing the PB against hypopressive exercises (OH and HB), this study's results suggest that hypopressive exercises facilitate the activation of the Tra/IO similar to bridge exercises while it reduces RA and EO activity. The execution of a combined bridge exercise plus hypopressive exercise (HB) boosts the Tra/IO and EO activation and decreases RA activity. As other studies suggest, hypopressive training is a valid alternative to activating the abdominal muscles, isolating the Tra/IO at low IAP and high intensity.

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