DOI: 10.1590/1809-2950/15727523042016

ORIGINAL RESEARCH

Effects of training with *Kinect Sports* and *Kinect Adventures* in the resistance of lumbar-pelvic muscles of healthy young adults: non-randomized clinical trial

Efeitos do treinamento com Kinect Sports *e* Kinect Adventures *na resistência da musculatura lombopélvica de adultos jovens saudáveis: ensaio clínico não randomizado*

Los efectos del entrenamiento con Kinect Sports *y* Kinect Adventures *en la resistencia de la musculatura lumbar y pélvica de adultos jóvenes saludables: estudio clínico no aleatorio*

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ABSTRACT | Exergames training (EXG) has been used as a technique for health prevention, however, little is known about its influence on the endurance of lumbar-pelvic muscles. The effects of *Kinect Sports*® and *Kinect Adventures*® on the endurance of lumbar-pelvic muscles in healthy young adults were analyzed. Forty participants (26 women and 14 men, from 18 to 30 years old) were sorted by convenience into a control group (CG, n = 20) and an intervention group (IG, n=20). The muscles of the trunk (flexor, extensor and lateral flexor) were assessed in three periods: before the intervention (T0), after five weeks (T5) and after 12 weeks (T12). Only the IG underwent training with *Kinect Sports*® and *Kinect Adventures*® (XBOX360 Kinect®), in pairs, twice a week, during 12 weeks. To analyze the differences between groups, mixed ANOVA test was used with repeated measures design 2 (treatment group: CG vs. IG) x3 (lumbar-pelvic complex tests: T0 vs. T5 vs. T12) ($p<0.05$). The IG showed a significant increase in the endurance of trunk extensors and lateral flexors ($F_{2,76}=3.947$, $p=0.03$; $F_{2,76}=3.763$, $p=0.02$), respectively, after 12 weeks of intervention, compared to the CG. It was concluded that EXG training (XBOX360 Kinect Sports® and Kinect Adventures®) improved the resistance of the lumbar-pelvic muscles of healthy young adults. This protocol may be considered an instrument for the prevention of musculoskeletal disorders in the lumbar region.

Keywords | Video Games; Health Promotion; Spine.

RESUMO | O treinamento com exergames (EXG) tem sido utilizado como técnica para prevenção em saúde, embora pouco se saiba sobre sua influência na resistência da musculatura da região lombopélvica. Assim, analisou-se os efeitos dos jogos *Kinect Sports*® e *Kinect Adventures*® sobre a resistência muscular da região lombopélvica de adultos jovens saudáveis. Tivemos 40 participantes (26 mulheres e 14 homens, com idade entre 18 e 30 anos) divididos por conveniência em grupo controle (GC, n=20) e grupo intervenção (GI, n=20), e submetidos a avaliações da resistência da musculatura flexora, extensora e flexora lateral do tronco, em três períodos: inicial (T0), depois de cinco semanas (T5) e depois de 12 semanas (T12). Somente o GI realizou treinamento com *videogame*, jogos *Kinect Sports*® e *Kinect Adventures*® (Xbox 360 Kinect®), em duplas, duas vezes por semana, durante 12 semanas. Para analisar as diferenças entre os grupos foi utilizado o teste de ANOVA mista com medidas repetidas *design* 2 (grupo de tratamento: GC *vs.* GI) x3 (testes do complexo lombopélvico: T0 *vs.* T5 *vs.* T12) ($p<0,05$). Resultados: O GI apresentou aumento significativo da resistência de extensores de tronco e flexores laterais de tronco

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($F_{2,76}$=3.947, p=0,03; $F_{2,76}$=3.763, p=0,02, respectivamente) depois de 12 semanas de intervenção com o *videogame*, em comparação ao GC. Concluiu-se que o treinamento com EXG (Xbox 360 *Kinect Sports®* e *Kinect Adventures®*) incrementou a resistência da musculatura da região lombopélvica de adultos jovens saudáveis. Este protocolo pode ser considerado na prevenção de desordens musculoesqueléticas da região lombar.
Descritores | Jogos de Vídeo; Promoção da Saúde; Coluna Vertebral.

RESUMEN | El entrenamiento con los videojuegos activos viene siendo empleado como técnica para promover la salud, pero todavía poco se sabe acerca de su influencia en la resistencia de la musculatura lumbar y pélvica. En este trabajo se analizaron los efectos de los juegos Kinect Sports® y Kinect Adventures® en la resistencia de la musculatura lumbar y pélvica de adultos jóvenes saludables. Se dividieron 40 participantes (26 mujeres y 14 varones, con edades entre 18 y 30 años) por conveniencia en el grupo control (GC, n=20) y en el grupo de intervención (GI, n=20), y se les sometieron al análisis de resistencia del músculo flexor, extensor y flexor lateral del tronco, en tres periodos: inicial (T0), después de cinco semanas (T5) y después de 12 semanas (T12). El G1 solo realizó entrenamiento con los videojuegos Kinect Sports® y Kinect Adventures® (Xbox 360 Kinect®), en parejas, dos veces semanales, durante 12 semanas. En el análisis de las diferencias entre grupos se empleó la prueba ANOVA mixta con repetidas medidas design 2 (grupo de entrenamiento: GC vs. GI) x3 (pruebas del complejo lumbar y pélvico: T0 vs. T5 vs. T12) ($p<0,05$). Comparado al GC, el GI presentó un aumento significativo en la resistencia de los extensores del tronco y en los flexores laterales del tronco ($F_{2,76}$=3.947, p=0,03; $F_{2,76}$=3.763, p=0,02, respectivamente) tras las 12 semanas de entrenamiento con los videojuegos. Se concluye que el entrenamiento con videojuegos activos, Xbox 360 Kinect Sports® y Kinect Adventures®, mejoró la resistencia de la musculatura lumbar y pélvica de los participantes, y puede ser empleado en la prevención de trastornos musculoesqueléticos lumbares.
Palabras clave | Videojuego; Atención a la Salud; Columna Vertebral.

INTRODUCTION

The stability of the lumbar-pelvic complex aims to maintain the balance of the spine within physiological limits, in order to protect structural integrity and reduce dislocation caused by disturbances[1].

Evidences suggest that lumbar-pelvic disorders are more often caused by changes in muscle recruiting (time, amplitude and resistance) than by changes in muscle force[1,2]. Lumbar-pelvic stability contributes to the control of movements of the trunk and pelvis in relation to the lower extremities; allowing, thus, the production, dissipation and transfer of power during the movement[1,2]. Therefore, lumbar-pelvic instability is considered a risk factor for the onset of lumbar pain, postural changes and structural degenerative processes[3,4]. Considering this, studies[5-7] point out that different forms of core exercises contribute to lumbar-pelvic stabilization; however, without presenting significant differences when compared with traditional exercises.

Since training with exergames (EXG) has become a great ally to the practice of physical exercises[8], in a pleasurable manner[9], requiring users to use different physical-motor abilities, we have hypothesized that its practice may be considered an attractive alternative for healthy young adults to maintain lumbar-pelvic stabilization. Studies that have examined the effects of EXG training in healthy adult individuals[10-13] verified increased strength[12], static and dynamic balance[10,12], physical activity level[13] and activity of the medial gastrocnemius and anterior tibialis muscles[11].

Siriphorn & Chamonchant[12] verified a significant increase in the strength of the lower limbs muscle groups (hip flexors, knee flexors, dorsiflexors and plantar flexors) in young adults, after training with the *Nintendo Wii Balance Board*, two times a week, 30 minutes a day, for eight weeks, using six yoga exercises and five strength exercises. Such results can be justified by the choice of the games, which involved, mostly, movements in the lower limbs.

Park et al.[11] verified significant improvement of the myoelectric activity of the anterior tibialis and gastrocnemius muscles, however, no significant change was observed in the trunk flexors (rectus abdominis) and extensors (spinal erectors) in healthy young adults, after six weeks of training (*Nintendo Wii Fit*®) with tennis, baseball and bowling games, during 40 minutes, three times a week. The authors attributed the results to the types of game chosen, which demanded larger movements of the lower limbs, compared to the trunk. However, longer periods of training, i.e., over six weeks, should be investigated concerning the response of the muscles of the lumbar-pelvic complex.

Therefore, no study has verified the effects of EXG training involving different movements of the trunk, with weekly training frequency of less than three times a week, for more than eight weeks, on the strength of the muscles of the lumbar-pelvic region of healthy young adults.

Thus, the present study aimed to analyze the effects of EXG training with *Kinect Sports*® (volleyball and track & field games) and *Kinect Adventures*® (river rush and reflex ridge games), involving different movements of the trunk and limbs, performed two times a week for 30 minutes, for 12 weeks, on the resistance of the core lumbar-pelvic muscles (flexors, extensors and lateral flexors of the trunk) of healthy young adults.

METHODOLOGY

It is a non-randomized controlled clinical trial, approved by the Research Ethics Committee of the Health Sciences Department of the Federal University of Paraná (UFPR) (CAAE 18541213.7.0000.0102) in which all the participants signed an informed consent form.

Healthy young adults were invited to participate in the study, through informative lectures about EXG. To be included in the study, the subjects needed to be between 18 and 30 years old, of both genders and enrolled at the university; to not have chronic, cardiovascular, musculoskeletal and/or neurological diseases; to not have been subjected to a surgery in the year preceding the participation in this study; and to have time availability for the training and evaluations. The minimum frequency of 75%[14] was established for abidance to the training and in the final analysis of the results.

The sample size was calculated using the formula described by Luiz and Magnanini[15] maintaining a 95% confidence level, a significance level of 0.05 (type I error) and 80% power (type II error). The sample number estimated for the hypotheses of this study was of 16 individuals per group. In order to prevent sample loss by the end of the study, 20 individuals were admitted in each group.

The individuals were distributed by convenience, according to their preference, in the Control Group (CG) and in the Intervention Group (IG). Both groups were assessed individually by a single evaluator prior to the intervention (T0) and reassessed after five weeks (T5) and 12 weeks (T12).

The evaluation of the lumbar-pelvic complex (Figure 1) included four tests[16-18] of evaluation of isometric muscle strength, through the registration of the maximum time (in seconds) the participants could hold the test position, with the use of a timer (*Kadio*, KD1069®). The following muscle groups were evaluated: (1) TF-trunk flexors (rectus abdominis). The participant was instructed to remain in supine position, with the upper body bent at 60°, the knees and hips at 90° and arms crossed over the chest (Figure 1A), for the maximum time possible. The test was terminated when the participant could not hold the position with a 60° trunk flexion. Holding the position for 149 seconds was considered appropriate for women and 144 seconds for men[16,17]; (2) TE-trunk extensors (dorsal longissimus and multifidus). The participant was placed in ventral decubitus, with the trunk suspended, but with the superior iliac crests supported on the edge of the evaluation table and the lower limbs fixed by the evaluator (Figure 1B). The participant was instructed to hold the position, with their arms crossed over the chest for as long possible. Holding the position for 146 seconds was considered appropriate for men and 189 seconds for women[16,17]; (3) LF-lateral trunk flexors (quadratus lumborum, internal and external obliques). The participant was positioned in lateral decubitus, supporting the weight of their body on one of their forearms and on the extended ipsilateral lower limb (Figure 1C). The participant was instructed to put the hand which was not being supported on their contralateral shoulder, to lift their hip from the mat with the spine aligned and to remain in the lateral pillar bridge position for as long as possible. Holding the position for 96 seconds was considered appropriate for men and 75 seconds for women[16,17]; and (4) (AFE) associated trunk flexors and extensors. The participant was placed in ventral decubitus, with elbows and shoulders at 90° and instructed to stay in a prone pillar bridge position, supporting only their toes and forearms on the mat (Figure 1D), for the maximum time possible. Holding the position for 60 seconds was considered appropriate for both genders[17,18].

After the evaluation (T0), the IG was subjected to EXG training with the XBOX360 *Kinect*® console, in pairs, twice a week for 30 minutes, in the period of 12 weeks. Two games from *Kinect Sports*® (volleyball and track & field) and *Kinect Adventures*® (river rush and reflex ridge) were used. The choice of the games occurred due to them encompassing basic motor skills such as: ducking, jumping, raising and lowering the arms, spinning and tilting the trunk. In addition, these games stimulate more complex motor skill, with associated movements like jumping and hitting the ball (imitating the movement of serving and/or setting the ball in a game of volleyball) or running in place (performing the movements of hip and knee flexion, considering the higher the angle, the faster the participant will be running in the game). The intervention program was held in a room without objects that could interfere in the performance of the participant, with them being positioned in front of the *Kinect*® sensor at a 3 meters distance, in accordance with the manufacturer's recommendations. The *Kinect Sports*® and *Kinect Adventures*® games were applied in an interleaved manner, with one of them being carried out in each intervention, and the levels of difficulty increased according to the improvement in the performance of the pairs during the practices.

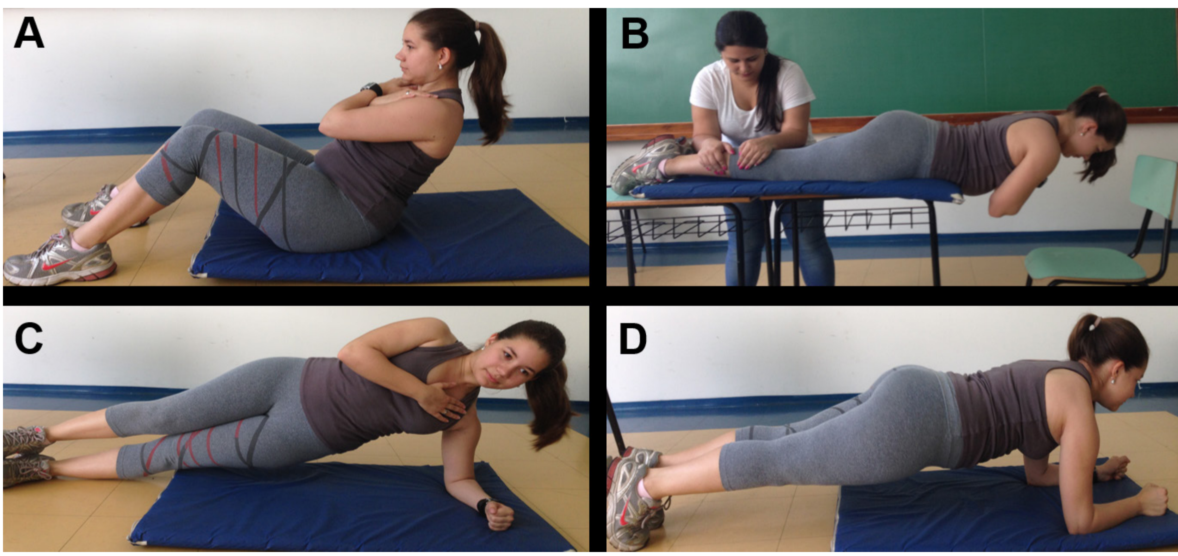

Figure 1. Position of execution of the clinical trials for assessment of the isometric strength of trunk muscles. (A) Trunk flexors; (B) trunk extensors; (C) lateral trunk flexors; (D) associated trunk flexors and extensors

The CG was not subjected to EXG training and were told to go on with their daily life activities during the study period.

The statistical analyses were carried out with the statistical software *Statistical Package for Social Sciences* (SPSS) for Windows, version 22.0. The data were presented as mean±standard error of the mean and subjected to analyses of variance homogeneity and sphericity through the *Mauchly* and *Levene* tests, respectively. To analyze the differences between the groups, mixed ANOVA test was used with repeated measures design 2 (treatment group: control vs. intervention) x3 (lumbar-pelvic complex tests: T0 vs. T5 vs. T12). The significance level was set at $p<0.05$. The size of the effect was determined through Eta-squared[19], 2=0.01 being considered a small effect, 2=0.059 a medium effect and values of 2 above 0.138, a large effect.

RESULTS

Forty undergraduate students participated, distributed in the Control Group (CG, n=20, 13 female and seven male, 21.85±0.62 years old) and in the Intervention Group (IG, n=20, 13 female and seven male, 23.10±0.61 years old) who underwent an EXG training program for 12 weeks. None of the participants discontinued training, as shown in the flow diagram (Figure 2). All participants from the IG finished training with a minimum of 91.6% adhesion, i.e., only 2 absences during the 12 weeks of training.

The IG showed significant increase in the isometric strength of the trunk extensor (TE) and lateral flexor (LF) muscles, both with moderate magnitude of effect ($F_{2,76}=3.947$, $p=0.03$, $\eta^2=0.094$; $F_{2,76}=3.763$, $p=0.02$, $\eta^2=0.090$), respectively. Contrasts revealed that the increase occurred between T0 vs T12 ($F_{1,38}$=5.713, p=0.02, η^2=0.131; $F_{1,38}$=5.961, p=0.01, η^2=0.136), respectively, in both analyses. However, despite the average increase in the isometric strength of the trunk extensor (TE) and associated (TFE) muscles, there was no significant interaction ($F_{2,76}$=1.769, p=0.18, η^2=0.044; $F_{2,76}$=1.706, p=0.18, η^2=0.043, respectively).

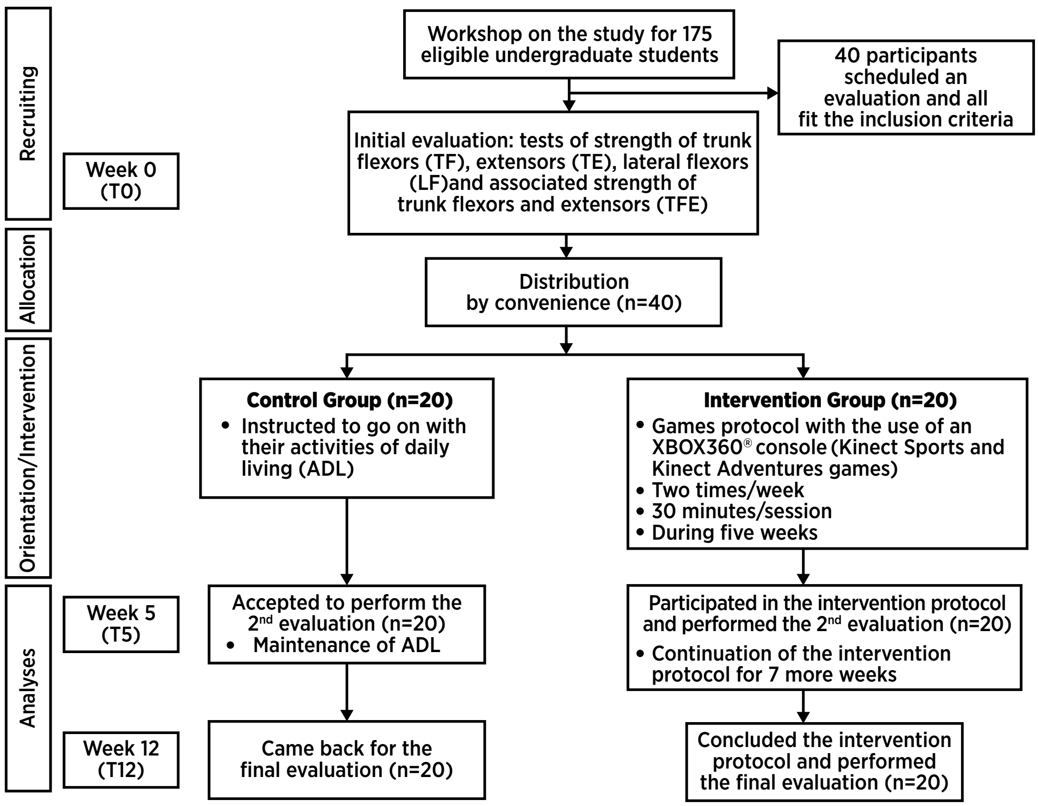

Figure 2. Flowchart of the study

Table 1. Values of the tests of lumbar-pelvic muscle strength in seconds (mean±MSD) of the control (CG) and intervention (IG) groups, measured before the intervention (T0), after five weeks (T5) and after 12 weeks (T12)

Muscle group assessed	Group	T0 (seconds)	T5 (seconds)	T12 (seconds)	p-value
TF-Trunk flexors	CG	86.48±11.9	89.37±12.4	90.94±11.7	0.18
	IG	88.33±11.0	104.79±10.2	115.28±8.3	
TE-Trunk extensors	CG	113.60±11.9	115.71±12.6	110.23±11.7	0.03*
	IG	123.66±11.5	147.48±10.8	150.84±11.4**	
LF-Lateral trunk flexors	CG	33.63±6.3	36.30±6.2	35.34±6.1	0.02*
	IG	44.86±5.7	48.44±6.1	56.66±5.7**	
TFE-Trunk flexors and extensors	CG	39.92±4.2	42.26±4.2	40.53±4.0	0.18
	IG	48.74±4.2	51.45±4.0	55.63±2.8	

* p<0.05 mixed ANOVA main effect with repeated measures; **p<0.05 by contrasts in relation to T0xT12

DISCUSSION

The physical training conducted through *Kinect Sports®* (volleyball and track & field games) and *Kinect Adventures®* (river rush and reflex ridge games), held only two times a week, was able to increase the isometric strength of the trunk extensor and lateral flexor muscles after 12 weeks. These outcomes indicate that the games used in this study could improve the stabilization of lumbar-pelvic muscles in healthy young adults.

Lumbar-pelvic stability is a result of the interdependent activity of the passive, active and neural subsystems[20]. The passive subsystem, consisting of the joint structures of the spine, has as its main function sending information to the neural control subsystem through mechanoreceptors, providing stability. The active subsystem consists of the muscles of the trunk and provides the spine with dynamic stabilization. Finally, the neural subsystem, formed by the structures of the nervous system, responsible for the input and output of signals, maintains lumbar-pelvic stability, through the continuous and integrated activity of the three subsystems[1,2]. Thus, the interaction between the subsystems is needed for stability and exercise programs can be specified to enhance this integration. In the present study, the *Kinect Sports*® and *Kinect Adventures*® games used probably activated the integration between the systems, since they were positive for the improvement of the lumbar-pelvic core muscles.

The increased strength of the trunk extensor and lateral flexor muscles can be attributed to the training protocol used in this study, for having emphasized the performing of resistance, plyometrics, neuromotor and core exercises. The stability of the core refers to the ability to stabilize the column through muscle activity, which can be incremented with sports activities and complex motor control exercises, encompassed by the *Kinect Sports*® and *Kinect Adventures*® games in this study.

A recent study[11] with young adults who trained using the Nintendo *Wii Fit*® console, with the tennis, bowling and baseball games three times a week for 40 minutes/session, during six weeks, found a significant increase in the muscle activity of the medial gastrocnemius and anterior tibialis muscles, however, they did not observe significant improvement of the myoelectric activity of trunk muscles. On the other hand, in the present study, conducted with a 30-minute duration, only two times a week, an increase in the isometric muscle endurance of the trunk extensor and lateral flexor muscles was found after 12 weeks of training. Thus, it is suggested that the games used in this study required greater demand for the use of the lumbar-pelvic muscles in the adopted training. Thus, it is believed that the choice of the games should consider the region which is intended to be improved, respecting the principle of specificity, and the training period must not exceed 12 weeks, for greater responsiveness of the lumbar-pelvic muscles of young adults.

We suggest that the gains obtained are related with the movements required to perform the practice of the selected games. Movements of lateral flexion, extension, flexion and rotation of the trunk, as well as movements of the trunk in association with the members, jumping and avoiding obstacles, demand contractions of the aforementioned muscles[22], resulting in significant improvements in the evaluated outcomes.

Also, according to the outcomes obtained, it is suggested that the protocol with EXG, through the *Kinect Sports*® and *Adventures*® games, can be considered an important strategy to promote musculoskeletal health, especially in relation to the improvement of the isometric strength of lumbar-pelvic muscles. However, few studies have assessed the effects of training with different types of EXG in the trunk muscles of healthy populations.

Nitz et al.[23] found increased muscle strength of the quadriceps, hip adductors and abductors after training with the *Nintendo Wii Balance Board*, two times a week, 30 minutes a day, for 10 weeks in healthy middle-aged women. Sato et al.[24] evaluated muscle strength in healthy elders before and after training with the Kinect (Kinect SDK version 1.5 Unity version 3.4.2) for 40 minutes per day, two to three times a week, for a total of up to 24 times; significant improvement in muscle strength having been found in the group that carried out the training, through the test of sitting and getting up in 30 seconds.

Study limitations

The present study has some limitations, such as: risk of bias due to the lack of randomization, non-blinding of the appraisers, lack of intervention in the control group with conventional exercises without the XBOX360 console and absence of more in-depth neuromuscular analyses, such as the evaluation of the myoelectric activity of the lumbar-pelvic region.

It is thus suggested that new studies are conducted with sample randomization, blind assessment and inclusion of intervention with conventional exercises in the control group. Finally, it is suggested to conduct a follow-up to check the duration of the results and the effects of EXG on the resistance of lumbar-pelvic muscles, both in healthy individuals, as in individuals with musculoskeletal dysfunctions.

CONCLUSION

With this study it was possible to conclude that the EXG protocol performed with the XBOX 360

Kinect® console, only two times a week, was able to increase the strength of the lumbar-pelvic muscles (extensors and lateral flexors) of healthy young adults, after 12 weeks of intervention. Thus, it is suggested that EXG may contribute to improving the stability of the lumbar-pelvic region, through the increase of muscle endurance, and possibly prevent musculoskeletal disorders.

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