Journal of Physical Education and Sport ® (JPES), 16(2), Art 63, pp. 407 - 412, 2016
online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Original Article

Pilates Exercise to Improve Lower limb strength and Abdominal endurance in the workplace

YA-WEN TSAI[1], KUO-MING WANG[2]*
[1]Graduate Institute of Health Allied Education, National Taipei University of Nursing and Health sciences, Taipei, Taiwan, REPUBLIC OF CHINA
[2]Department of Physical Medicine and Rehabilitation, Taoyuan Armed Forces General Hospital, Taoyuan, Taiwan, REPUBLIC OF CHINA

Published online: June 25, 2016
(Accepted for publication May 11, 2016)
DOI:10.7752/jpes.2016.02063

Abstract
Problem statement: Work-related musculoskeletal pain can also impact on quality of life in office workers.
Approach: This study adopted the Polestar^{TM} Pilates method to explore the effect of Pilates exercise on the lower limb strength and abdominal endurance of workplace employees. Participants were selected from six workplaces and the quasi-experimental design was used. Only the experimental group received Polestar^{TM} Pilates exercise training, which was given by a certified Pilates trainer. Both groups received a pretest and posttest of lower limb strength and abdominal endurance.
Results: After 12 weeks of Pilates training, the lower limb strength and abdominal endurance of the experimental group was significantly enhanced.
Conclusions: This current study provides an example of Pilates exercise intervention for workplace health promotion of preventing chronic disease, lower back pain and serves as an important reference for tracking the progress of preventing chronic disease, musculoskeletal pain and inhance the quality of life in workplaces.
Keywords: Chronic diseases; physical fitness; Pilates intervention; Worksite health promotion

Introduction

Low muscle strength has been shown to be associated with poor cardiorespiratory functions and an increased risk of falling (Barbat-Artigas et al., 2010; MacGilchrist et al., 2010). Levinger et al. (2009) also described low muscle strength may also be associated with an unfavorable metabolic risk profile, which may affect exercise capacity, and the capacity to perform activities of daily living and quality of life. In recent years, work-related cardiovascular diseases (CVD) have gained growing attention in Taiwan and its neighboring countries, such as Japan and Korea where long working hours and high stress at work are commonplace (Cheng, Park, Kim, & Kawakami, 2012). Office workers work in a sitting position without moving for long periods of time; they only use a few specific muscles of their arms, wrists and hands; and they tend to adopt poor body posture (Macedo, Trindade, Brito, & Socorro Dantas, 2010). These working patterns generate musculoskeletal disorders and can lead to discomfort or pain (Macedo et al., 2010) which can have an impact on quality of life (van der Roer, Ostelo, Bekkering, van Tulder, & de Vet, 2006). Moreover, physical inactivity is thought to make office workers prone to physical deconditioning, which is characterised by lower physical capacity and reduced muscle strength (Bousema, Verbunt, Seelen, Vlaeyen, & Knottnerus, 2007).

Regular exercise can improve physical fitness, but exercise that is too intense or strenuous runs the risk of causing injuries (Finch & Cassell, 2006). Pilates is a mind/body exercise that requires core stability, strength, flexibility, and attention to muscle control, posture, and breathing (Latey, 2002). Pilates exercise is performed solo in one's own space, so there is no risk of collision or other contact with others. The risk of injury to the musculoskeletal system is therefore minimized, making Pilates a relatively safe form of exercise (Latey, 2002; Wells, Kolt, & Bialocerkowski, 2012). In most of the literature discussing the relationship between the Pilates exercise and adult physical fitness, the studies in question were conducted primarily in foreing countries (Bird et al., 2012; Donahoe-Fillmore et al., 2007; Otto et al.,2004; Rogers & Gilbson, 2009; Sekendiz et al., 2007); the duration of the interventions ranged from 4 to 12 weeks (Donahoe-Fillmore et al., 2007; Rogers & Gilbson, 2009; Sekendiz et al., 2007) and the sample size of around 30 participants (Otto et al.,2004). Studies were primarily focused on effects of the Pilates exercise on body composition, trunk flexibility and posture stability (Donahoe-Fillmore et al., 2007; Otto et al., 2004; Wells et al., 2012). A combination of strength and endurance training in elderly populations has been postulated as the most effective strategy for improving neuromuscular and cardiorespiratory functions, to maintain functional capacity, and to promote health (Cadore et al., 2011; Holviala et al., 2010). The workplace has become a key target for health promotion programmes aimed at increasing physical activity and preventing chronic disease (WHO, 2002a,b; WHO & World Economic Forum, 2008). Many workplace health promotion programs have aimed at reducing cardiovascular diseases and

Corresponding Author KUO-MING WANG, E-mail: kuomine@hotmail.com

musculoskeletal pain (Carnethon et al., 2009; Lloyd-Jones et al., 2010). However, very few studies were conducted in Asia, especially in Taiwan (Huang, Lin, Yen, Kan, & Chen, 2013). Because there has been very little study on this important subject in Taiwan, this current study investigates the effects of the Polestar Pilates™ technique (Polestar Pilates Education, 2007) on office worker lower limb muscle strength, and abdominal muscle endurance.

Methods

Design and Participants

This current study adopted the quasi-experimental design, and participants were divided into two groups (experimental group and control group). Pre-test were given to all participants on the day of acceptance, and Post-test were given at the end of a 12 week period. Only the experimental group received the Polestar Pilates™ intervention (one hour of exercise, twice a week, for 12 weeks). Participants selected for this current study were from six workplaces in Taipei City. Inclusion criteria were: 1)20 years of age or older, 2) never experienced Pilates exercise, and 3) never been diagnosed with spinal disease, sciatica, systemic disease, or had conditions rendering them unsuitable for Pilates exercise (such as severe cardiovascular disease, joint replacement, patellofemoral pain syndrome etc.).

125 volunteers met the criteria profiles and agreed to participate, and they were assigned to their respective groups. Data was only recorded for those with an attendance rate of 67% or higher. 88 participants met the data collection standard, comprised of 53 in the experimental group, and 35 in the control groups.

Setting and Process

Participants were asked to sign a consent form and requested not to change their own habits of exercise or activities of daily living during the research process. All participants engaged in a pretest of lower limb muscle strength and trunk flexibility one week prior to the intervention being started. The experimental group received Pilates exercise training (60 min per session, twice a week for 12 consecutive weeks) and the control group received no exercise intervention whatsoever, although they may have been participating in their own exercise routines outside of the study setting. The testing settings were the same for both groups, and exercise was scheduled after work to suit the needs of the respective institutions. The experimental group participants attended the exercise classes at their respective institutions to facilitate their attendance at classes. Posttests were conducted within one week of the end of the 12-week intervention, and testing was conducted in the same locations.

Exercise Intervention Program

Polestar Pilates principles and the Pilates Group Mat Exercise Intervention Program were conducted in this current study (Otto et al., 2004). The number of participants was limited to 12 people per class. The classes were conducted by a qualified trainer with Polestar Pilates certification, and supervised by a qualified physical therapist who also had Polestar Pilates certification. Their presence was aimed at ensuring the accuracy of moves performed by the participants during the exercise program implementation (see Appendix for the complete contents of the program).

Research instruments

Research instruments used in this current study include: background data, lower limb muscle strength, abdominal muscle endurance, and Polestar Pilates™ certified Pilates courses.

Background data- included marital status, level of education, family income, chronic disease, daily sitting posture duration, and exercise habits.

Lower limb muscle strength: muscle strength was determined using an electronic dynamometer (T.K.K. 5102 Back D, Takei Scientific Instruments Co., Ltd, Niigata, Japan) with standardized protocols (Arslan, 2005). The subjects put their feet on the dynamometer with their knees bent 130–140^{o}. They held the handle in a stretched position, and the chain was fixed to form the desired knee angle. The measurement was taken when the subject stretched the legs slowly but powerfully up without using the muscles on the back. The test was performed three times, with a 1-minute break between tests. The best individual test result achieved was recorded to the kilogram.

Abdominal muscle endurance: the static endurance test was used. To measure the static endurance of the abdominal muscles, the subjects were instructed to curl up with straight arms pointing toward their knees until their iliac crests were raised from the table, and to hold this posture for a maximum of 240 seconds (Kofotolis & Kellis, 2006). During the test, researchers visually checked the subjects' body mechanics to ensure compliance. Verbal instructions on correct positioning were provided only at the start of the test. The test was terminated when the subject could not maintain the required position.

***Pilates course*:** Polestar Pilates™ exercises were adopted over a 12 week period; the Pilates group mat training intervention was provided twice a week and one hour each time. There were 12 participants for each course, and it was administered by a Polestar Pilates™ certified Pilates instructor and supervised by a Polestar Pilates™ certified physiotherapist to ensure that the postures of the participants are accurate.

Data Analysis

Descriptive statistical analyses were used to describe subject variable distributions using means, standard deviations, frequencies and percentages. Independent t-test and Chi-square were used to examine differences between the experimental group and the control group in terms of pre-test scores. A paired t-test was used to assess differences between pre-test and post-test lower limb muscle strength and abdominal muscle endurance for both experimental and control groups. Using the pretests of the 2 groups as the covariates, ANCOVA was conducted to determine the posttest differences between the 2 groups. The significance level for all statistics was set to *p*□0.05.

Results

Personal Background

88 effective samples were collected: 53 from the experimental group (mean age: 42.3±9.6 range 26-62); 35 from the control group (mean age: 40.2±10.6 range 28-59). The remaining participants' data and their demographic profiles are listed in Table 1. The independent-sample *t* test and Pearson's chi-square test found no significant differences between the experimental and control groups with respect to age, height, weight, pre-test, marital status, education level, chronic disease, time spent sitting, and exercise habits ($p > 0.05$ in all items). .

The pre-tests in lower limb muscle strength and abdominal muscle endurance were compared for the 2 groups using the independent-sample *t* test, as shown in Table 2, and no significant difference emerged ($p > 0.05$).

Table 1. Demographic characteristics of the participants

Items	EG (n=53)			CG (n=35)			p	
	M	±	SD	M	±	SD		
Age (y)	42.3	±	9.6	40.2	±	10.6	0.333	a
Height (cm)	161.9	±	5.9	159.5	±	6.1	0.075	a
Weight (kg)	60.6	±	11.9	56.3	±	8.1	0.066	a
Sex	N	(%)		N	(%)		0.472	b
male	9	(16.9)		4	(11.4)			
female	44	(83.1)		31	(88.6)			
Marital status							0.564	b
yes	18	(33.9)		14	(40.0)			
no	35	(66.1)		21	(60.0)			
Education level							0.317	b
high school	7	(13.2)		3	(8.5)			
college	40	(75.4)		24	(68.5)			
master degree	6	(11.4)		8	(23.0)			
Chronic disease							0.437	b
none	47	(88.7)		28	(80.0)			
others (diabetes mellitus, hypertension ,arthritis)	6	(11.3)		7	(20.0)			
Time spent sitting							0.119	b
<4 h a day	18	(33.9)		6	(17.1)			
4-6 h a day	11	(20.7)		13	(37.1)			
>6 h a day	24	(45.4)		16	(45.8)			
Exercise habits							0.391	b
none	14	(26.2)		14	(40.0)			
1-2 times a week	22	(41.5)		11	(31.4)			
irregularly	17	(32.3)		10	(28.6)			

NOTE. a: Independent sample t test; b: Chi-Square test EG: experimental group; CG: control group

Table 2. Comparison of pretest results between groups for lower limb strength and abdominal endurance

Items	Experimental (n=53)			Control (n=35)			95% CI		*t* test	*p-values*
	M	±	*SD*	*M*	±	*SD*	Low	High		
Lower limb Strength (kg)	57.7	±	25.7	54.8	±	22.0	-7.5	13.5	0.56	0.576
Abdominal endurance (sec)	77.8	±	37.7	86.2	±	39.6	-25.1	8.2	-1.00	0.319

Differences in lower limb muscle strength and abdominal muscle endurance between pre-test and post-test

Changes in lower limb muscle strength and abdominal muscle endurance after the Pilates exercise intervention were shown in Table 3. There were significant improvements in lower limb muscle strength ($t=-4.15$, $p<0.001$) and abdominal muscle endurance ($t=-7.04$, $p<0.001$) in the experimental group, while not in the control group. The results indicated that after 12 weeks of the Pilates exercise intervention, the experimental group exhibited a significantly higher level of improvement for their lower limb muscle strength and abdominal muscle endurance than that of the control group.

Table 3. Comparison of lower limb strength and abdominal endurance

Items	Pretest		Posttest		95% CI		Paired-*t*	*p*-values
	M	± *SD*	*M*	± *SD*	Low	High		
Experimental group (n=53)								
Lower limb Strength (kg)	57.7	± 25.7	63.3	± 25.7	-10.9	-0.6	-4.15	0.000***
Abdominal endurance (sec)	77.8	± 37.7	111.1	± 19.6	-42.8	-23.8	-7.04	0.000***
Control group (n=35)								
Lower limb Strength (kg)	54.8	± 22.0	52.6	± 21.9	-2.4	6.6	0.94	0.355
Abdominal endurance (sec)	86.2	± 39.6	94.4	± 36.0	-18.3	2.0	-1.62	0.114

*** $p < 0.001$

Effects of Polestar Pilates™ intervention on lower limb muscle strength and abdominal muscle endurance
Statistical process control was required to compare Pilates exercise intervention effects to eliminate significant differences between both groups before the Pilates exercise intervention, because of the quasi-experimental design. Therefore, pre-test results for both groups were used as the covariate for ANCOVA when comparing the effects of exercise intervention. Before ANCOVA, the homogeneity of the withinclass regression coefficient was checked to determine whether the slope of each group was the same, a fitness determinant of the homogeneity hypothesis. Table 4 indicates Pilates exercise intervention on lower limb muscle strength and abdominal muscle endurance achieved a statistically significant difference (lower limb muscle strength: $F = 13.94$, $p <0.001$; abdominal muscle endurance: $F=15.98$, $p<0.001$). The adjusted mean for experimental and control groups was 65.3 and 52.6 kg (muscle strength); 33.3 and 8.1 seconds (muscle endurance) respectively, indicating that after 12 weeks of the Pilates exercise intervention, experimental group exhibited a significantly higher level of improvement for their lower limb muscle strength and abdominal muscle endurance than control group after the ANCOVA (using pre-test results for both groups as the covariate).

Table 4. Results of ANCOVA for posttest results, using pretest as the covariate (n=88)

	Groups	*M*±*SE*		*F-values*	*p*-values
Lower limb Strength (kg)	Experimental	65.3	± 25.7	13.94	0.000***
	Control	52.6	± 21.9		
Abdominal endurance (sec)	Experimental	33.3	± 34.4	15.98	0.000***
	Control	8.1	± 9.7		

*** $p < 0.001$

Disscusion
As far as author's knowledge, this current study is the only research to focus on the effects of Pilates exercise intervention on lower limb muscle strength and abdominal muscle endurance in workplace. This current study discovered that a 12-week Pilates exercise intervention 1 hour per session, twice a week could significantly improve lower limb muscle strength. The results of current study reinforce discoveries by empirical studies (Otto, et al., 2004; Rogers & Gilbson, 2009; Sekendiz et al., 2007). The results also confirmed that training 1 hour per session, twice a week for 12 weeks can significantly improve abdominal muscle endurance in adults, and this findings are supported by other studies (Otto et al., 2004; Rogers & Gilbson, 2009; Sekendiz et al., 2007). The duration of the Pilates exercise courses administered in previous studies ranged from 8 to 12 weeks, and positive results were attained (Kloubec, 2010; Otto et al., 2004; Rogers & Gilbson, 2009).

By comparing earlier studies that focused on abdominal muscle endurance as the measurement index, the static endurance test was used in this current study but not dynamic (Kloubec, 2010; Rogers & Gilbson, 2009; Sekendiz et al., 2007). Richardson, Toppenberg and Jull (1990) pointed that stability in abdominal region is necessary to protect the lumbar spine and associated structures from injury. Emphasis on this stabilizing role should be primary consideration when designing an isometric exercise program to improve endurance in the abdominal muscle groups. McGill (2004) also showed that postural defects and deformities occur as a result of a decrease in the static endurance of the postural muscles. A decrease in the static endurance of the abdominal and lumbar musculature influences the occurrence of a muscular inbalance in the region (McGill, 2004). The results of current study showed that Pilates exercise can improve static abdominal endurance significantly, and can effectively protect the lumbar an abdominal regions from injury.

Empirical studies indicate that muscle weakness is closely related to several chronic diseases (i.e. poor cardiorespiratory functions, metabolic risk and poor quality of life) (Barbat-Artigas et al., 2010; Levinger et al., 2009; MacGilchrist et al., 2010). Abdominal muscle endurance is an essential component of fitness for health, maintaining proper alignment, prevents low back pain and supporting movements of both the lower and upper extremities in activities of daily living and work performance (Hildenbrand & Noble, 2004; McNeil et al., 1980). This current study have been confirmed that 12 weeks, 1 hour per session, twice a week Pilates exercise intervention can significantly improve the lower limb muscle strength and trunk endurance for office workers. The findings serve as an important reference point for advancing workplace health promotion of preventing chronic disease, cardiovascular diseases, lower back pain and maintaining proper posture alignment for employees.

Limitations

Potential limitations of this current study are as follows. First, because of budgets and workforce limitations, the post-test was carried out immediately after the 12 weeks of Pilates exercise intervention without any subsequent follow-up testing. Thus, it remains unkown how long the improvement in the lower limb muscle strength and abdominal muscle endurance from the 12 weeks of training will last after the study is terminated. Second, this current study adopted a quasi-experimental design, and it was conducted only on six workplaces in Taipei City, and the size of the effective sample was only 88 test subjects. Thus, it cannot be extrapolated to apply to all populations in Taiwan. Third, this current study adopted Polestar Pilates™ methods for the experiment design and intervention, and the result cannot be applied to traditional Pilates exercises.

Implications for practice

The implications of this research are significant. This current study provides an example of Pilates exercise intervention for workplace health promotion of preventing chronic disease, lower back pain.

In order to prevent occupational health hazards and to develop working conditions, the employer must arrange occupational health care services for employees using proper health care professionals and consultants. Joining the occupational health service system is voluntary for entrepreneurs. In a time of economic recession, the design of a cost effective program to promote the health of the employees has become a workplace challenge. The participants in this current study were instructed and supervised by certified trainers, and no one was injured in the Pilates exercise. This affirmed the viewpoint that Pilates exercise is a highly safe form of exercise. Pilates mat exercise does not require special facilities and equipment, and can be practiced in nearby communities, classrooms, and conference rooms at a school or workplaces. This makes it convenient for everyone to regularly practice Pilates exercise.

Conclusions

After 12 weeks of Pilates exercise intervention, the lower limb muscle strength and abdominal muscle endurance has significantly improved for office workers, and the magnitude of the muscle strength and endurance improvements of experimental group was significantly higher than those of the control group. It is hoped that this results may provide a reference to draw up personal exercise plans for similar workplaces. However, it should be noted that most studies of Pilates exercise have been conducted using only female adults as study subjects. Pilates exercise is also a relatively a static form of exercise. During the study subject recruitment process, it was discovered that some male applicants perceived that the Pilates mat exercise is not challenging enough. Some Pilates postures, however, are indeed difficult, and can challenge the muscle strength, muscle endurance, flexibility and sense of balance of all exercise participants. Future studies are recommended to increase the percentage of adult male participants to 50% of the test sample, or independently focus on the benefits of Pilates exercise on the physical fitness of adult males.

References

Arslan, C. (2005). Relationship between the 30-second wingate test and characteristics of isometric and explosive leg strength in young subjects. *Journal of Strength & Conditioning Research, 19*(3), 658–666.

Barbat-Artigas, S., Filion, M.E., Ringuet, M.E., Aubertin-Leheudre, M., & Karelis, A.D. (2010). Relationship between Low Muscle Strength and Metabolic Risk Factors in Obese Postmenopausal Women: A Pilot Study. *Canadian Journal of Diabetes, 36*, 269-274.

Bird, M.L., Hill, K.D., & Fell, J.W. (2012). A randomized controlled study investigating static and dynamic balance in older adults after training with Pilates. *Archives of Physical Medicine & Rehabilitation, 93*(1),43-49.

Bousema, E.J., Verbunt, J.A., Seelen, H.A., Vlaeyen, J.W., Knottnerus, J.A. (2007). Disuse and physical deconditioning in the first year after the onset of back pain. *Pain,* 130, 279–86.

Cadore, E.L., Pinto, R.S., Lhullier, F.L.R., Correa, C.S., Alberton, C.L., Pinto, S.S., Almeida, A.P.V.,Tartaruga, M.P., Silva, E.M., Kruel, L.F.M. (2011). Effects of strength, endurance andconcurrent training on aerobic power and dynamic neuromuscular economy in elderly men. *Journal of Strength & Conditioning Research*, *25*, 758–766.

Carnethon, M., Whitsel, L. P., Franklin, B. A., Kris-Etherton, P., Milani, R., Pratt, C. A.,et al. (2009). Worksite wellness programs for cardiovascular disease preven- tion: a policy statement from the American heart association. *Circulation, 120*(17), 1725 -1741.

Cheng, Y., Park, J., Kim, Y., Kawakami, N. (2012). The recognition of occupational diseases attributed to heavy workloads: experience in Japan, Korea, and Taiwan. *International Archives of Occupational and Environmental Health,85*(7),791–9.

Donahoe-Fillmore, B., Hanahan, N. M., Mescher, M. L., Clapp, E. D., Addison, N. R., & Weston, C. R. (2007). The effects of a home Pilates program on muscle performance and posture in healthy females: a pilot study. *Journal of Women's Health Physical Therapy, 31*(2), 6-11.

Finch, C., & Cassell, E. (2006). The public health impact of injury during sport and active recreation. *Journal of Science & Medicine in Sport, 9*, 490-497.

Hildenbrand, K., & Noble, L. (2004). Abdominal Muscle Activity While Performing Trunk-Flexion Exercises Using the Ab Roller, ABslide, FitBall, and Conventionally Performed Trunk Curls. *Journal of Athletic Training. 39*(1), 37-43.

Holviala, J., Häkkinen, A., Karavirta, L., Nyman, K., Izquierdo, M., Gorostiaga, E.M., Avela,J., Korhonen, J., Knuutila, V.-P., Kraemer, W.J., Häkkinen, K. (2010). Effects of combined strength and endurance training on treadmill load carrying walking performance in aging men. *Journal of Strength & Conditioning Research*, *24*, 1584–1595.

Huang, J. J., Lin, H. S., Yen, M., Kan, W. M., & Chen, C. H. (2013). Effects of a workplace multiple Cardiovascular Disease risks reduction program. *Asian Nursing Research, 7*(2), 74-82.

Kloubec, J.A. (2010) Pilates for improvement of muscle endurance, flexibility, balance, and posture. *Journal of Strength & Conditioning Research, 24*(3), 661-667.

Kofotolis, N., and Kellis, E. (2006). Effects of two 4-week proprioceptive neuromuscular facilitation programs on muscle endurance, flexibility, and functional performance in women with chronic low back pain. *Physical Therapy 86*(7), 1001-1012.

Latey, P. (2002). Updating the principles of the Pilates method—part 2. *Journal of Bodywork & Movement Therapies, 6*(2), 94-101.

Levinger, I., Goodman, C., Hare, D.L., Jerums, G., & Selig, S. (2009). Functional capacity and quality of life in middle-age men and women with high and low number of metabolic risk factors. *International Journal of Cardiology, 133*(2), 281-283.

Lloyd-Jones, D. M., Hong, Y., Labarthe, D., Mozaffarian, D., Appel, L. J., Van Horn, L. et al. (2010). Defining and setting national goals for cardiovascular health promotion and disease reduction: the American heart association's strategic impact goal through 2020 and beyond. *Circulation, 121*(4), 586 - 613.

Macedo, A.C., Trindade, C.S., Brito, A.P., Socorro Dantas, M. (2010). On the effects of a workplace fitness program upon pain perception: a case study encompassing office workers in a Portuguese context. *Journal of Occupational Rehabilitation, 21*(2), 228–233.

MacGilchrist, C., Paul, L., Ellis, B.M., Howe, T.E., Kennon, B., Godwin, J. (2010). Lower-limb risk factors for falls in people with diabetes mellitus. *Diabetic Medicine, 27*, 162–168.

McGill, S. (2004). Ultimate back fitness and performance. Waterloo, Ontario, Canada: "Wabundo Publishers".

McNeil, T., Warwick, D., Andersson, G.B., Schultz, A. (1980). Trunk strengths in attempted flexion, extension, and lateral bending in healthy subjects and patients with low back disorders. *Spine. 5*,529–538.

Otto, R., Yoke, M., McLaughlin, K., Morrill, J., Viola, A., & Lail, A. et al. (2004). The effect of twelve weeks of pilates vs resistance training on trained females**.** *Medicine & Science in Sports & Exercise, 36*(5) Suppl. S356-S357.

Polestar Pilates Education. (2007). *Polestar Pilates principles of movement*. Miami: Polestar Education LLC.

Richardson, C., Toppenberg, R., Jull, G. (1990). An initial evaluation of eight abdominal exercises for their ability to provide stabilisation for the lumbar spine. *Australian Journal of Physiotherapy 36 (1)*, 6–11.

Rogers, K., & Gilbson, A. L. (2009). Eight-week traditional mat Pilates training program effects on adult fitness characteristics. *Research Quarterly for Exercise & Sport, 80*(3), 569-574.

Rodrigues, B.G.S., Cader, S.A., Torres, N.V.O., Oliveira, E.M., Dantas, E.H.M. (2010). Pilates method in personal autonomy, static balance and quality of life of elderly females. *Journal of Bodywork & Movement Therapies, 14* (2), 195-202.

Sekendiz, B., Altuna, O., Korkusuz, F., & Akin, S. (2007). Effects of Pilates exercise on trunk strength, endurance and flexibility in sedentary adult females. *Journal of Bodywork & Movement Therapies, 11*, 318-326.

van der Roer, N., Ostelo, R.W., Bekkering, G.E., van Tulder, M.W., de Vet, H.C. (2006). Minimal clinically important change for pain intensity, functional status, and general health status in patients with nonspecific low back pain. *Spine, 31*, 578–82.

Wells, C., Kolt, G.S., & Bialocerkowski, A. (2012). Defining Pilates exercise: a systematic review. *Complementary Therapies in Medicine, 20*(4), 253-262.

World Health Organization (WHO), 2002a. WHO STEPS instrument. Department of Chronic Diseases and Health Promotion, World Health Organization, Geneva.

World Health Organization (WHO), 2002b. Good practice in occupational health services: a contribution to workplace health. In: WHO Regional Office for Europe, (Ed), Copenhagen.

World Health Organization & World Economic Forum, 2008. Preventing Non- communicable Diseases in the Workplace through Diet and Physical Activity: WHO/World Economic Forum Report of a Joint Event. World Health Organization, Geneva.