Effect of Core Stabilization Exercise on Spatio-Temporal Gait Parameters in Patients with Total Hip Arthroplasty: A Randomized Controlled Trial

Hisham M. Ibrahima[1], Neveen. Abdelraof[2], Amr A. Azzam[3], Yasser M. Aneisb[2]

[1]Researcher of Physical Therapy, Basic Sciences Department, Faculty of Physical Therapy, Cairo University, Egypt

[2]Department of Basic Sciences, Faculty of Physical Therapy, Cairo University, Egypt

[3]Consultant of Orthopedic Surgery, The National Institute of Neuromotor System, Egypt.

Abstract

Objectives: Despite post-total hip arthroplasty (THA) rehabilitation, deficits in gait and muscle strength are still evident years after the procedure. The purpose of this study was to investigate the effect of core stabilization exercise on the spatio-temporal gait parameters in patients with THA. Methods: In this randomized controlled trial, sixty post-THA patients of both genders aged 50-65 years were randomly assigned to either; group A, the intervention group (n = 30), received ten weeks of conventional physical therapy followed by four weeks of core stabilization exercises in addition to aerobic exercise in the form of treadmill training; or group B, the control group (n = 30), received ten weeks of conventional physical therapy followed by 4 weeks of aerobic exercise training in the form of treadmill training. Spatio-temporal gait parameters; BOS, step length, stride length, gait velocity, and cadence were assessed pre-and post-intervention. Results: The within-group analysis demonstrated a significant increase in step length, stride length, cadence and gait velocity and a significant decrease in BOS ($P < 0.02$). Between-group differences were noteworthy, favoring the intervention group ($P < 0.002$).Conclusions: Adding a 4-week of core stabilization exercises to conventional physical therapy for THA has demonstrated remarkable improvements in spatio-temporal gait parameters, highlighting it as a superior choice.

Key words: Total hip arthroplasty, Conventional therapy, Core stabilization exercises, Gait, Rehabilitation.

1. Introduction

Total hip arthroplasty (THA), one of the most important surgical procedures in medical history, is a crucial choice for treating a number of advanced hip disorders that impede the joint's ability to function. This surgery helps about a million patients a year all over the world. Although osteoarthritis is the most frequent indication, the surgery can also be used to treat other disorders, including hip dysplasia, femoral neck fracture, and avascular necrosis of the femoral head, hip dysplasia, and inflammatory arthritis (Serfaty, 2020).

The hip joint is crucial for keeping the body balanced and in an upright posture. One of the two primary strategies for maintaining a steady, vertical body posture is the hip strategy, along with the ankle strategy. The research by Sasagawa et al. reveals that the hip strategy may be vital in accomplishing this task, even though most studies stated that the ankle technique had a predominate role during quiet standing.

Hip osteoarthritis patients who experience chronic pain and physical activity restrictions experience decreased proprioception, asymmetrical limb loading, and dynamic balance problems as a result. In addition, muscle strength deficits and a limited range of motion in people with severe hip arthritis bring on gait problems and a higher risk of falling. Up to 45% of patients with hip joint osteoarthritis experienced one fall in the previous year, according to Arnold and Faulkner. These disorders persisted for at least a year following joint replacement. It is well known that total hip replacement (THR) damages the periarticular tissues and damages or destroys the nearby receptors that detect movement and joint position (Wareńczak et al., 2019).

The optimal function of the lumbo-pelvic-hip muscles is hypothesized to improve trunk stability and muscle coordination, as well as lower injury risk. The lumbo-pelvic-hip complex's stability is important because it helps to prevent injuries by transmitting force from the lower extremities to the pelvis and spine, as well as stabilizing the pelvis during activities (Chang et al., 2017).

Theories were offered about the link between core stability and lower extremity function, performance, and injury. He proposed that motor activity in the form of postural support must exist before voluntary extremities motions can be initiated. Furthermore, the support must be adjusted based on the parameters of the anticipated movement, posture, and the level of uncertainty about the forthcoming duties (Willson et al., 2005). Hence, the present study aimed to investigate the effect of core stabilization exercise on the spatio-temporal gait parameters in patients with total hip arthroplasty.

2. Methods

2.1. Ethical considerations

The Ethical Board of the Faculty of Physical Therapy, Cairo University, has approved the trial (no: P.T.REC/012/003412). This study was reported in the

doi.org/10.31838/hiv23.03.63 Received: 16.10.22, Revised: 07.11.22, Accepted: 16.12.22.

Pan African Clinical Trial Registry with a record number (PACTR201801002854243). Each participant provided written consent and understood the right to withdraw from the study at any time.

2.2. Design

A single-blinded, randomized, controlled trial.

2.3. Setting

This study took place in the physical therapy outpatient clinic of sports injuries center in Cairo, Egypt.

2.4. Sample size estimation

The sample size was determined using the G*Power software (version 3.0.10, Germany). Based on F tests (multivariate analysis of variance: MANOVA repeated measures, within-between interactions, 60 patients were adequate sample size, with Type I error 0.05, power 80%, and effect size 0.37.

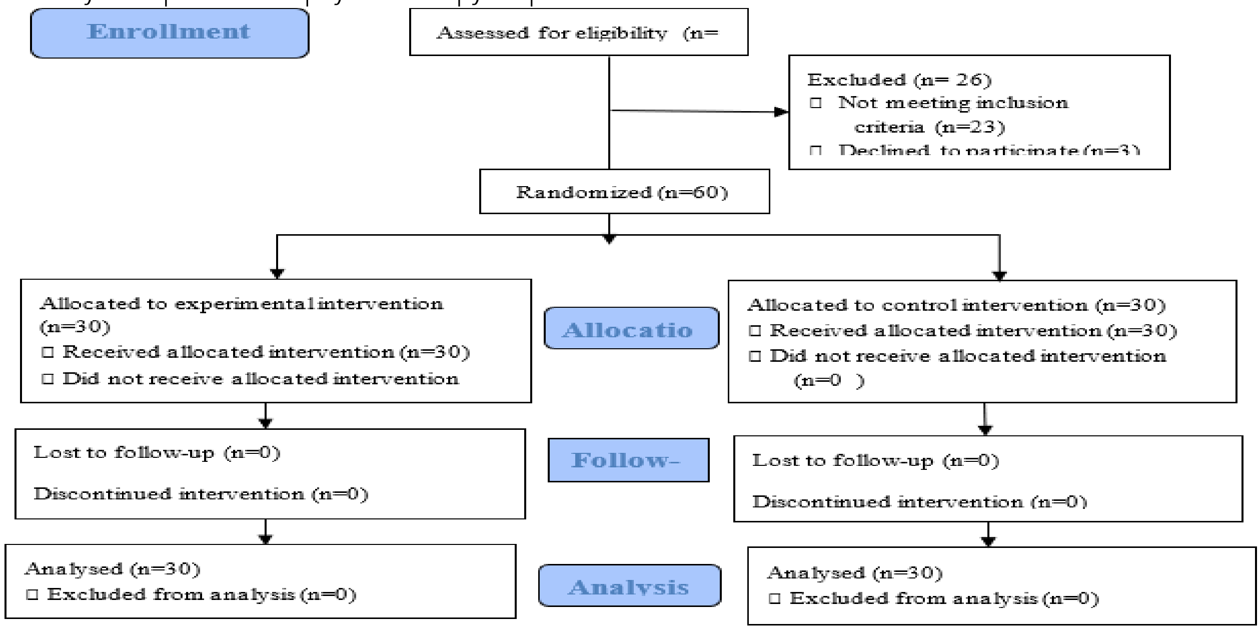

Figure (1): Flow diagram of the study

2.5. Patient recruitment and allocation

Sixty patients of both genders aged 50-65 years were randomly recruited from Nasser institute and Kasr al Aini hospital, Cairo, Egypt, from December 2021 to September 2022. The exclusion criteria were as follows: history of neurological conditions, such as hemiplegia, peripheral neuropathy, Parkinson's disease, multiple sclerosis or spinal cord compression, and vestibular disorders that might affect balance or not able to communicate or follow the instructions.

Patients who met the study's eligibility criteria were randomly allocated to either group A (intervention group, n=30) who received ten weeks of conventional physical therapy for total hip arthroplasty followed by four weeks of core stabilization exercises in addition to aerobic exercise in the form of treadmill training or group B (control group, n = 30) who received ten weeks of conventional physical therapy followed by 4 weeks of aerobic exercise training in the form of treadmill training. Participants were randomized in a 1:1 ratio using computer generated block randomization, followed by a concealed allocation by opening sequentially numbered and sealed envelopes; a card inside revealed the group assignment.

2.6. Outcome measures

The Outcome measures were the spatio-temporal gait parameters; BOS, step length, stride length, gait velocity, and cadence. All measures were assessed at the beginning of the study and at the end of the study for both groups.

2.7. Assessments

Spatio-temporal gait parameters

A digital camera Nikon D3200 Full HD recorded gait video, resolution 1280 × 720 pixels at 50 frames per second (fps). The AF-S DS NIKKOR 18–55 mm lens at the minimum available zoom was used. It was located perpendicular to the participant at 2.5 m and 1 m above the floor. The participants were instructed to walk along the 11-meter walkway. They were instructed to walk at a comfortable gait speed that they chose for themselves. Two markings were placed at two meters apart on the footbridge that the subjects had to walk to delimit the recording area. When the participants entered the recording area, the recording began and ended when they exited. In each session, five repetitions for each subject were recorded. After that, the data was analyzed with kinovea software to determine the spatiotemporal gait parameters. (pilar et al., 2020)

2.8. Intervention Procedures

Subjects in the intervention group received ten weeks of conventional physical therapy for total hip arthroplasty (Mariana & Maria, 2015), appendix I, followed by four weeks of core stabilization exercises in addition to aerobic exercise in the form of treadmill training while subjects in control group received ten weeks of conventional physical therapy followed by 4 weeks of aerobic exercise training in the form of treadmill training.

Rehabilitation Protocol

Initial contact occurred after the surgery and before discharge, when information about the study was provided to patients. At that time, eligible patients were identified, invited to participate, and received verbal and written information about the trial (background, procedure, and randomization). The patients received a consent form and a referral for physical therapy, which started after suture removal (2 weeks postoperatively). After obtaining informed consent from each participant the baseline information were collected at the time of the first physical therapy session. The spatio-temporal gait parameters were evaluated at baseline and post-intervention (14 weeks postoperatively).

Core stability exercise

Core stability exercise began with recognition of the neutral spine position (the mid-range between lumbar flexion and extension), which is regarded as the position of power and balance (Akuthota et al., 2004). The first stage training involved learning to activate the musculature of the abdominal wall. Abdominal hollowing, which activates the transversus abdominis, as well as abdominal bracing, which activates many muscles including the transversus abdominis, external obliques, and internal obliques. Hicks et al., 2003, and Barnet et al., 2005 showed that performing abdominal hollowing and bracing prior to performing abdominal curls facilitated activation of the transversus abdominis and internal obliques throughout the abdominal curling activity. Once these activation techniques were mastered and the transversus abdominis was "awakened," training progressed. The protocol then incorporated the "big 3" exercises. These include the curl-up, side bridge (side plank), and quadruped position with alternate arm and leg raises (the "bird dog"). Then the prone plank and bridging could be added (Arokoski et al., 2004). Initial exercises were done in supine, hook-lying, or quadruped positions. Normal, rhythmic diaphragmatic breathing was also emphasized. Once good control was achieved with the static core exercises, the individual could advance to exercises using a physio ball. (Stanton et al., 2004).

Appendix I Conventional physical therapy for total hip arthroplasty

Weeks postoperative	Lower-limb weight-bearing/ Assistive device for walking	Description
2-4	Partial/walker	• Stretching (30 seconds per muscle group): hip flexors, extensors, and adductors; knee flexors, extensors; ankle dorsiflexors, and plantar flexors. • Active assisted range of motion (5 to 10 repetitions): hip flexion, extension, abduction, external rotation; knee flexion, extension. • Muscle strengthening (1 to 3 sets of 10 to 15 repetitions): hip flexors, extensors, abductors (low-resistance rubber band fixed to the ankle in standing position). Knee extensors (seated with a sandbag around the ankle). • Transfer training includes supine to sidelying in bed, as well as sitting and standing in bed and chair. • Gait training using a parallel bar and assistive device.
4-6	Total/crutch or cane	• Stretching maintained • Active range of motion (5–10 repetitions): hip flexion, extension, abduction, external rotation; knee flexion, extension. • Muscle strengthening (1 to 3 sets of 10 to 15 repetitions): hip flexors (moderate-resistance rubber band fixed to the ankle in standing position); hip abductors (standing position and seated position with moderate-resistance rubber band); hip extensors (bridge exercise, one- and two-footed in supine position); and knee extensors and flexors (weight-training equipment, in a seated position, 20% of 1RM). • Balance and gait training: walking on an unstable surface, backward walking, sidestepping with the use of parallel bars if necessary.
6-8	Total or with/without cane	• Stretching maintained • Muscle strengthening (1–3 sets of 10–15 repetitions): maintain hip flexors and abductors; hip extensors (bridge exercise, one- and two-footed in supine position with ball). • Climbing and descending stairs. • Coordination, balance, and gait training: circuits with stairs, obstacles, changing directions, and changing speeds.
8-10	Total	• All exercises are maintained. • Addition of the strengthening of hip and knee extensors with squat exercises (1–3 sets of 10–15 repetitions).

.9. Statistical analysis

The unpaired t-test was conducted for comparison of subject characteristics between groups. The normal distribution of data was checked using the Shapiro-Wilk test. Levene's test for homogeneity of variances was conducted to test the homogeneity between groups. A mixed MANOVA was conducted to investigate the effect of treatment on gait parameters. Post-hoc tests using the Bonferroni correction were carried out for subsequent multiple comparisons. For all statistical tests, the level of significance was set at $P < 0.05$. All statistical analysis was conducted through the Statistical Package for Social Studies (SPSS) version 25 for Windows (IBM SPSS, Chicago, IL, USA).

3. Results

The analysis of the data showed no significant difference between groups in age, weight, height, BMI and sex distribution ($P > 0.05$), as illustrated in Table 1.

Table 1. Patients' demographic characteristics at baseline					
	Study group	Control group	MD	t- value	*P*-value
	Mean ±SD	Mean ±SD			
Age (years)	57.4 ± 4.39	58.36 ± 4.39	-0.96	-0.85	0.39
Weight (kg)	84.9 ± 11.24	84.36 ± 10.77	0.54	0.18	0.85
Height (cm)	176.6 ± 7.42	175.73 ± 8.82	0.87	0.41	0.68
BMI (kg/m²)	27.17± 2.92	27.11 ± 2.37	0.06	0.09	0.92
Sex, n (%)					
Females Males	10 (33%) 20 (67%)	10 (33%) 20 (67%)			1*
SD, Standard deviation; MD, Mean difference; p value, Probability value; *, Value estimated by Chi squared.					

Effect of treatment on spatio-temporal gait parameters

Mixed MANOVA revealed a significant interaction effect of treatment and time (F = 144.64, p = 0.001, partial eta-squared = 0.95). There was a significant main effect of treatment (F = 8.5, p = 0.001, partial eta-squared = 0.57). There was a significant main effect of time (F = 249.17, p = 0.001, partial eta-squared = 0.97).

Within group comparison

There was a significant improvement in all gait parameters post-treatment in study group (p < 0.001) and control group (p < 0.05) compared to pre-treatment. The percent of change in step length, stride length, BOS, cadence and speed of study group was 43.46, 40.40, 36.33, 19.65 and 29.41% respectively and that in control group was 6.64, 8.49, 2.92, 1.61 and 9.62% respectively.

Between group comparison

There was no significant difference between groups pre-treatment (p > 0.05). Comparison between groups post treatment revealed a significant increase in step length, stride length, cadence and step and a significant decrease in BOS of study group compared with that of control group post-treatment (p < 0.01).

Table 2. Mean gait parameters pre- and post-treatment of study and control groups					
	Pre-treatment	Post-treatment			
	Mean ±SD	Mean ±SD	MD	% of change	*P*-value
Step length (cm)					
Study group	35.71 ± 6.21	51.23 ± 5.06	-15.52	43.46	0.001
Control group	34.96 ± 6.07	37.28 ± 5.67	-2.32	6.64	0.01
MD	0.75	13.95			
P-value	*P* = 0.64	*P* = 0.001			
Stride length (cm)					
Study group	64.29 ± 8.82	90.26 ± 6.77	-25.97	40.40	0.001
Control group	63.74 ± 9.43	69.15 ± 9.18	-5.41	8.49	0.001
MD	0.55	21.11			
P-value	*P* = 0.81	*P* = 0.001			
BOS (cm)					
Study group	17.12 ± 2.19	10.90 ± 2.02	6.22	36.33	0.001
Control group	17.78 ± 2.31	17.26 ± 2.02	0.52	2.92	0.02
MD	-0.66	-6.36			
P-value	*P* = 0.25	*P* = 0.001			
Cadence (step/min)					
Study group	72.11 ± 7.01	86.28 ± 6.71	-14.17	19.65	0.001
Control group	71.94 ± 8.98	73.1 ± 9.27	-1.16	1.61	0.02
MD	0.17	13.18			
P-value	*P* = 0.93	*P* = 0.001			
Speed (m/s)					
Study group	0.51 ± 0.08	0.66 ± 0.08	-0.15	29.41	0.001
Control group	0.52 ± 0.11	0.57 ± 0.11	-0.05	9.62	0.001
MD	-0.01	0.09			
P-value	*P* = 0.63	*P* = 0.002			
SD, Standard deviation; MD, Mean difference; p value, Probability value					

4. Discussion

Our study was conducted to investigate the effect of core stabilization exercise on spatiotemporal gait parameters in patients who recently underwent total hip arthroplasty. The study revealed no significant difference between groups pretreatment (P>0.05). comparison between groups post treatment revealed a significant increase in step length, stride length, cadence, speed and a significant decrease in BOS of the study group compared to the control group (P<0.01).

These findings are consistent with those of previous studies and can be explained that core stabilization exercise increased posterior tilt of the pelvis and COG transfer during the swing phase through core training. Core training might improve the stability of the lower trunk and pelvis and result in increased ability with regard to static balance, dynamic balance, and weight support of the more affected side and ultimately may contribute to a more stable gait (Chung et. al. 2013).

The transverse abdominis is involved in preparation of body during contralateral weight shifting. Studies show that trunk muscle activity, especially transverse abdominis and multifidus precedes the lower and upper limb muscular activity. It is also believed that such feed-forward recruitment pattern of core musculature provides a more stable neuromuscular foundation for muscular movement and can contribute to more precise limb control during locomotion (Hodges and Richardson, 1997).

These findings are supported by many previous studies reported that the core stabilization exercises improves the gait performance and normalizes the spatiotemporal gait parameters. Choi et al., 2012 Reported that trunk stabilization exercise using Swiss ball could improve balance and gait in elderly women. Balouchy et al., 2022 investigated the effect of 8 weeks of selected core stability exercises on static and dynamic balance, gait speed, and stride length of students with educable intellectual disability. The Results indicated that the exercise procedure adopted strengthens the static, active balance, gate speed, and length of students with intellectual disabilities.

Sharma and kuar, 2017 investigated the effects of core strengthening combined with pelvic proprioceptive neuromuscular facilitation (PNF) on trunk impairment, balance, gait, and functional ability of chronic stroke patients. The results indicated that core stabilization combined with pelvic PNF was more effective for improving trunk impairment, balance and gait of chronic stroke patients. Moreover Onwudiwe et al., (2018) investigated the effect of core strengthening activities on dynamic balance and gait speed in stroke survivors. There were significant differences in dynamic balance measurements and gait speed between the experimental and control groups.

Tehrani et al., 2018 conducted a study to compare the effects of eight weeks of core stability and Pilate's trainings on ankle proprioception, postural control, walking performance, self-efficacy and fear of falling in elderly women. The parameters under investigation were all significant post intervention relative to pre intervention. The authors concluded that Pilates and core stability trainings seem to be a complementary rehabilitation therapy that can be employed in medical centers to improve ankle proprioception, balance, walking performance, and lessen falls in elderly women.

However, the results of the current study disagree with Flowers et al., 2022 who investigated the effects of core stabilization training on patients with knee osteoarthritis (KOA) and concluded that the gait speed and external knee adduction moment changes met minimal detectable change thresholds after six-week core stabilization program. This discrepancy might be attributed to many reasons: First, the severity of KOA was not directly assessed or controlled for in the investigation. Therefore, these results cannot be applied to any particular severity grade(s) of KOA. Second, as with all motion analysis studies, there is the issue of possible marker placement error. Third, the vast majority (77.3%) of participants were female, therefore this too should be considered when applying these results clinically. Finally, there was no control group in this investigation, so comparing the outcomes of this core stabilization intervention to a standard of care treatment or no treatment is not possible. The limitations of this study are worth mentioning. There are no follow-up details that would allow us to track the long-term effects of this intervention; therefore, addressing this in future studies would be beneficial.

References

Akuthota, V., and S.F. Nadler. Core strengthening. Arch. Phys. Med. Rehabil. 85:86Y92, 2004.

Arokoski, J.P., T. Valta, M. Kankaanpaa, and O. Airaksinen. Activation of lumbar paraspinal and abdominal muscles during therapeutic exercises in chronic low back pain patients. Arch. Phys. Med. Rehabil. 85:823Y832, 2004.

Balouchy R. The Effect of 8 Weeks of Selected Core Stability Exercises on Static and Dynamic Bal-ance, Gait Speed, and Stride Length of Students with Intellectual Disability. J. Sport Inj Prev Biomech 2022; 1 (1) :35-44

Choi, Su-Hee & Lim, Jae-Heon & Cho, Hwa-Young & Kim, Il-Bok & Kim, Mo-Kyung & Lee, Hyun-Young. (2012). The Effects of Trunk Stabilization Exercise Using Swiss Ball and Core Stabilization Exercise on Balance and Gait in Elderly Women. Journal of the Korean Society of Physical Medicine. 7. 10.13066/kspm.2012.7.1.049.

Chung EJ, Kim JH, Lee BH. The effects of core stabilization exercise on dynamic balance and gait function in stroke patients. J Phys Ther Sci. 2013 Jul;25(7):803-6. doi: 10.1589/jpts.25.803. Epub 2013 Aug 20. PMID: 24259857; PMCID: PMC3820398.

Flowers, D.W.; Brewer, W.; Mitchell, K.; Ellison, J.; Frilot, C. The Effect of Core Stabilization Training on Improving Gait and Self-Perceived Function in Patients with Knee Osteoarthritis: A Single-Arm Clinical Trial. Pathophysiology 2022, 29, 495-506.

Hodges PW, Richardson CA. Contraction of the abdominal muscles associated with movement of the lower limb. Phys Ther. 1997;77:132–142.

Mariana Kátia Rampazo-Lacativa and Maria José D'Elboux, Effect of cycle ergometer and conventional exercises on rehabilitation of older patients with total hip arthroplasty: study protocol for randomized controlled trial. Rampazo lacativa and D`Elboux trials (2015)16:139.

Mihyang Chang, Lindsay V. Slater, Revay O. Corbett, Joseph M. Hart, Jay Hertel: Muscle Activation patterns of the lumbo-pelvic-hip complex during walking gait before and after exercise, Gait and posture 52 (2017) 15-21.

Onwudiwe, Chukwudi & Ikechukwu, EZEMA & Nweke, Martins & Anukam, G & Okoye, Goddy. (2018). EFFECTS OF CORE STRENGTHENING EXERCISES ON DYNAMIC BALANCE AND GAIT SPEED IN STROKE SURVIVORS. 47-54.

Pilar Fernández-González, Aikaterini Koutsou , Alicia Cuesta-Gómez, María Carratalá-Tejada, Juan Carlos Miangolarra-Page 2,3 and Francisco Molina-Rueda 2 .Reliability of Kinovea® Software and Agreement with a Three-Dimensional Motion System for Gait

Analysis in Healthy Subjects Sensors 2020, 20, 3154; doi:10.3390/s20113154.

Sasagawa S, Ushiyama J, Kouzaki M, Kanehisa H. Effect of the hip motion on the body kinematics in the sagittal plane during human quiet standing. Neurosci Lett. 2009 Jan 23;450(1):27-31. doi: 10.1016/j.neulet.2008.11.027. Epub 2008 Nov 17. PMID: 19027828

Serfaty A. Hip arthroplasty: current concepts and potential complications. Radiol Bras. 2020 Jan-Feb;53(1):VII. doi: 10.1590/0100-3984.2020.53.1e2. PMID: 32313341; PMCID: PMC7159045.

Sharma V, Kaur J. Effect of core strengthening with pelvic proprioceptive neuromuscular facilitation on trunk, balance, gait, and function in chronic stroke. J Exerc Rehabil. 2017 Apr 30;13(2):200-205. doi: 10.12965/jer.1734892.446. PMID: 28503533; PMCID: PMC5412494.

Stanton, R., P.R. Reaburn, and B. Humphries. The effect of short-term Swiss ball training on core stability and running economy. J. Strength Cond. Res. 18:522Y528, 2004.

Wareńczak, Agnieszka & Lisiński, Przemysław. (2019). Balance a few years after total hip replacement. 10.21203/rs.2.11747/v1.

Willson, John & Dougherty, Chris & Ireland, Mary & Davis, Irene. (2005). Core Stability and Its Relationship to Lower Extremity Function and Injury. The Journal of the American Academy of Orthopaedic Surgeons. 13. 316-25. 10.5435/00124635-200509000-00005.

Zohreh Naderi Tehrani, dan Khosro Jalali Dehkordi, 2018, The Effect of Eight Weeks of Core Stability and Pilates Trainings on Ankle Proprioception, Postural Control, Walking Performance, Self-efficacy and Fear of Falling in Elderly Women, Report of Health Care Volume 4, Issue 3, 2018, p. 1- 13 diakses pada tanggal 1 bulan juli 2020 dari http://jrhc.miau.ac.ir