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Amelioration of Kinaesthesia in Pregnant Women Using Pezzi Ball Exercises: Randomized Controlled Trial

Fayiz F. El-Shamy[1], Ahmed El Saied M[2] , Shereef Lotfy Elshwaikh[3], Eman A. Elhosary[1], Ibrahim Mohamed Hamoda[4] , Rania Elsayed Abdelaleem[5]

1 Department of Physical Therapy for Women's Health, Faculty of Physical Therapy, Kafrelsheikh University, Kafrelsheikh, Egypt.
2 Outpatient Clinic of Faculty of Physical Therapy, Kafrelshiekh University, Kafrelshiekh, Egypt.
3 Department of Obstetrics and Gynecology, Faculty of Medicine, Tanta University, Tanta, Egypt.
4 Department of Physical Therapy for Neurology and its Surgery, Faculty of Physical Therapy, Kafrelsheikh University, Kafrelsheikh, Egypt.
5 Kasr Ainy Cairo University Hospitals, Egypt.

Abstract
BACKGROUND: Some modifications to posture and gait occur during pregnancy which affect balance and increase the risk of falling. **PURPOSE:** The purpose of this study is to examine the short-term impact of kinaesthetic training on pregnant women's postural balance. **METHODS:** Thirty pregnant women were randomized to either the intervention group (KEG; n=15) which received kinaesthetic exercises on the Pezzi ball and standard care or the control group (CG; n=15) which received the standard care only. Performance and postural stability were measured using a balance check board 636-1 (BCB) and Mini-BESTest at 28 weeks gestation (WG),32 WG, and 2 weeks postpartum. **RESULTS**: Within-group analysis, performance, and postural stability increased significantly in KEG ($p < 0.05$) between 28 WG and 32 WG and between 28 WG and 2 weeks postpartum. There was no statistically significant difference in KEG performance and postural stability between 32 WG and 2 weeks postpartum ($p > 0.05$). Between-group analyses, there was no statistically significant difference in performance and postural stability ($p > 0.05$) before treatment between both groups at 28 WG, with a significant difference ($p < 0.05$) between both groups at 32 WG and 2 weeks postpartum. **CONCLUSION:** kinaesthetic training improves performance and postural stability during pregnancy and 2 weeks postpartum
Keywords: Pregnancy, Kinaesthetic exercises, Postural stability, Pezzi ball

1. INTRODUCTION

Throughout pregnancy, a multitude of modifications take place in the soft tissue, joints, posture, and gait [1, 2, 3]. These modifications are commonly caused by variations in the hormonal and musculoskeletal systems [4,5], leading to discomfort and instability in the lower extremities of pregnant women [6,7,8]. Moreover, these alterations may result in a decrease in postural stability and an increased vulnerability to falls [9,10,11]. Other significant modifications include a relocation of the center of mass towards the anterior direction [12,13], an increase in ligamentous laxity [4,5], a decrease in neuromuscular control and synchronization [14,15], a reduction in abdominal muscle strength, and an elevation in lumbar lordosis. The presence of mechanical fluctuations in plantar loading during pregnancy may potentially affect a woman's ability to execute motor actions efficiently, perhaps leading to deviations from normal postural alignment [16,17].

Within the demographic of pregnant women, a significant subset of 2.7% reported instances of multiple falls (more than twice). Nevertheless, it is crucial to emphasize that pregnant women who have reported experiencing at least one fall during their pregnancy are subject to a significantly elevated risk of falling, estimated to be roughly 24.3% [10]. After giving birth, there is a potential for falls to occur, however, the likelihood of this happening gradually decreases over a period of 6 to 8 weeks [13]. Accidental falls constitute 40% of the total emergency room visits and hospitalizations linked to trauma in pregnant individuals [18]. Slips and falls possess the capacity to yield various unfavorable consequences, such as fractures, head traumas, muscle strains, joint sprains, burst uteruses, placental separations, and in exceptional instances, maternal or fetal mortality [19].

The condition of being overweight has been found to have a significant influence on multiple aspects, including the expansion of the center of pressure (COP), postural balance, and susceptibility to falling [8,11,12]. The study reveals that pregnant women exhibit greater postural sway in a relaxed stance compared to women who are not pregnant, as evidenced by their center of pressure (COP) pathways [8]. The research conducted in this study revealed a significant decrease in the initial, total sway, and sway velocity of COP in the third trimester in comparison to the second trimester. The observed distinction was also apparent when contrasting the outcomes with those of persons who were not pregnant [11]. These modifications result in compensatory postural adjustments that possess the capacity to elicit Pain [20].

The utilization of Swiss-ball core training programs has evolved, shifting from their initial use in hospitals during the 1960s to their incorporation into modern-day gyms in the 21st century. These programs have garnered substantial recognition in the domain of physical therapy, as well as in strength and conditioning programs, owing to their capacity to augment strength and conditioning. Scholars frequently emphasize the benefits of including swiss-ball core training exercises into an individual's fitness regimen, as they efficiently contribute to spinal stability and improve balance [21]. These exercises serve to enhance the progression of muscular strength, endurance, proprioception, and neuromuscular control, hence fostering advancements in both strength and endurance. However, it is important to note that there is a dearth of empirical studies examining the effects of pezzi ball exercises on improving postural stability in pregnant women. Therefore, the main objective of this study is to analyze the short-term effects of kinesthetic balance exercise on dynamic postural stability in pregnant women, as well as during a follow-up evaluation two weeks after childbirth.

2. MATERIALS AND METHODS

2.1. Participants

The present study was carried out on 30 pregnant women, with ages ranging from 25 to 30 years. These participants were recruited from the Outpatient Clinic of the Faculty of Physical Therapy at Kafrelshiekh University. The individuals included in the study were randomly assigned to two groups: the study group, referred to as KEG, with a total of 15 participants, and the control group, referred to as CG, also consisting of 15 persons. The participants of the study group participated in a series of kinaesthetic balance exercises over a period of four weeks, doing three sessions per week. Each session had a duration of 30 minutes, which encompassed designated rest breaks aimed at avoiding fatigue. In contrast, the control group was provided with a brochure containing information regarding standard care, which was comparable to the informational material given to the study group. The eligibility criteria for both groups were defined as follows: a body mass index (BMI) not exceeding 32 kg/m2, low-risk gestation, a singleton pregnancy, and intact sensory motor integration in the lower extremities. The study excluded potential participants who met any of the following criteria: gestational age below 28 weeks, presence of multiple fetuses, the occurrence of pre-eclampsia, toxaemia, or gestational hypertension, history of previous abortion, and identification by their obstetrician as having a high-risk pregnancy. Furthermore, the study excluded individuals who had a previous diagnosis of Type I or Type II diabetes, as well as those with any other medical conditions that could potentially impact their sensation. Additionally, individuals with recent fractures in their legs, feet, ankles, or knees, pre-existing lumbar or knee pain, a history of cardiovascular, neurologic, neuromuscular, or pulmonary disorders, vertigo, balance issues, visual impairments, or psychological disorders were also excluded from the study. Likewise, pregnant individuals were excluded from the study if they engaged in smoking habits or were concurrently using any medications that could potentially impact their capacity to sustain equilibrium. In addition, it should be noted that any participant who failed to attend at least three sessions was excluded from the study. The investigation was carried out over the period spanning from March to August in the year 2023. The research utilized a design for a randomized controlled trial with a single-blinded approach, in which all participants provided written consent. The aforementioned action was carried out in adherence to the regulations established by the institutional review board and the Ethical Committee of the Faculty of Physical Therapy, Kafr Elshiekh University (No. P.T/WH/2/2023/36). The research utilized a design of randomized controlled trial, employing Microsoft Excel 2010 as the software for data handling. The process of randomization was carried out by generating a table of random numbers, where each number was assigned to either the KEG or CG group. Following this, the participants were assigned based on the corresponding numerical value of their allocation code. The study employed a strategy in which the researcher conducted the drawing without giving advance notice to the participants. This was done to determine the comparative efficacy of the KEG and CG procedures.

2.2. Evaluation procedure

Performance and postural stability were assessed in both groups at three-time points: baseline, four weeks after the intervention, and two weeks postpartum. The assessment was conducted using a balance checkboard 636-1 (BCB), which is a German-made device known for its ability to provide objective measurements of an individual's balance capacity on both stable and unstable surfaces. The BCB is recognized for its accuracy, repeatability, and validity [23]. It consists of a multi-axial standing platform that can be adjusted to different levels of tilt. It is possible to adjust the platform surface tilt to a maximum angle of 15 degrees. The participants were provided with the opportunity to choose between two conditions. In the first condition, they were instructed to concentrate on a visual feedback screen positioned directly in front of them. Their task was to maintain a circle at the center of the screen while standing on an unstable platform. In the second condition, participants were instructed to cross their upper limbs over their chest, thereby limiting the use of their arms for balance. The patients were given instructions to stand on the (BCB) device for one minute. During this time, they were required to maintain a double-limb stance without wearing shoes or stockings and with their eyes open. During the assessment period, the platform exhibited unrestricted movement and began to tilt along both the forward-backward and left-right axes.

The assessment of postural stability was conducted in both groups using the Mini Balance Evaluation Systems Test (Mini BESTest). The Mini-BESTest is comprised of a total of 14 items, which are further divided into four distinct components. These areas encompass anticipatory postural modifications, reactive postural control, sensory orientation, and dynamic gait. The first item pertains to the sit-to-stand movement, while the second item focuses on rising to the toes. The third item involves the task of standing on one leg, while the fourth, fifth, and sixth items address compensatory stepping corrections in the forward, backward, and lateral directions, respectively. The seventh item involves maintaining a stance with feet together and eyes open on a firm surface, while the eighth item explores the same stance but on a foam surface. The ninth item involves incline walking with eyes closed, while the tenth item examines changes in gait speed. The eleventh item involves walking with horizontal head turns, while the twelfth item focuses on walking with pivot turns. The thirteenth item involves stepping over obstacles, and the fourteenth item is the timed up-and-go task with a dual task component [25].

2.3. Intervention

Pregnant individuals were assigned to engage in KEG sessions through a random allocation technique. These sessions were comprised of three weekly sessions, each lasting 30 minutes. Before the implementation of the intervention, female participants in the intervention group were given a leaflet that offered comprehensive information on the knowledge improvement (KE) program. The intensity of the activity was controlled based on the maternal pulse frequency, which was detected using the Pulse Metre POD-3, Japan. During the intervention period, the participants in the intervention group solely participated in the kinesthetic exercise (KE) program, without receiving any supplementary physiotherapy treatments, such as pezzi ball exercises that target the improvement of static posture and performance [7]. The intervention group was provided with kinetic energy (KE) by a physiotherapist who possessed specific expertise in prenatal care and women's health issues. Each training group consists of five women. The pezzi ball exercises consist of a set of four consecutive phases. The first stage of the process entails the act of assuming a seated position on the ball and engaging in a bouncing motion after achieving equilibrium, with hands placed on the knees. The third phase involves a hip/twist movement, during which the individual adopts a seated position on the exercise ball. Upon attaining stability, the individual proceeds to cross their arms over their chest, afterward engaging in ten repetitions of clockwise hip rotation, followed by an equivalent number of counterclockwise rotations. The third stage encompasses the process of assuming a seated position or lifting one foot, during which the individual positions themselves on the ball and allows their hands to come to a rest. The third phase is adopting a seated posture on the exercise ball while concurrently elevating one leg. Adopt a sitting posture on the ball, ensuring that both hands and legs maintain contact with the ball. Flex the lower extremities, enabling the soles of both feet to make contact with the ground surface. To execute knee extension, the right knee should be extended in an anterior direction. The raised position should be sustained for two seconds, followed by returning the knee to its original resting position on the floor. Following this, proceed to completely extend your left knee and sustain this posture for two seconds. Execute a series of lower limb elevations while sustaining balance on a spherical entity. The patient is instructed to adhere to guidelines for standard care and proper posture when lifting and carrying heavy objects. Additionally, they are advised to use support pillows, perform bed turnovers without excessive strain on the lower back, and independently get out of bed. Furthermore, it is recommended that the patient maintains abdominal muscle engagement and a straight back during the third and fourth steps. Both groups of pregnant women were authorized to engage in physical exercise, specifically walking, except for the control group, who only received an instructive brochure as their intervention.

2.4 Measurement of Outcomes

The main measure of interest was the participants' performance, which was assessed using the BCB metric. The postural stability, as assessed by the Mini BESTest, served as the secondary outcome measure.

2.5. Sample-size calculation

The determination of the sample size was based on the pilot study conducted by El-Shamy et al. [26]. Given a sample size calculation with a power of 80% and a significance level of $p<0.05$, the study group is expected to experience a 30% enhancement in postural stability. To detect a difference in effect size of 5%, a total of 15 participants were deemed necessary.

2.6. Statistical analysis

The statistical analysis was performed using SPSS for Windows, version 26 (SPSS, Inc., Chicago, IL). The present experiment incorporated two distinct independent factors. The initial component under consideration was the tested group, which consisted of two levels: the study group and the control group. The second aspect of the study was the measuring periods, which consisted of three levels: pre-treatment, post 1, and post 2. Furthermore, this study incorporated two dependent variables that were assessed, namely performance and the mini BESTEST. Before doing the final analysis, the data underwent screening to assess the normality assumption, homogeneity of variance, and the existence of extreme scores. This investigation was conducted as a necessary step for performing parametric calculations in the analysis of variance. The box and whisker plots were constructed for the tested variable following the removal of outliers. A normality test was performed on the data using the Shapiro-Wilk test, which indicated that the data followed a normal distribution and did not violate the parametric assumption for the measured dependent variable. Furthermore, the assessment of covariance homogeneity indicated that there was no statistically significant distinction, as evidenced by p-values beyond 0.05. The aforementioned discoveries enabled the researchers to carry out a parametric analysis. A 2×3 mixed design multivariate analysis of variance (MANOVA) was employed to assess the differences in the variables of interest across several groups and time intervals. The alpha level was initially set at 0.05.

3. RESULTS

40 pregnant women who were first seen at the first appointment met the criteria for consideration. 30 participants (aged 25 to 30) from this group were randomly assigned to either the study or the control.

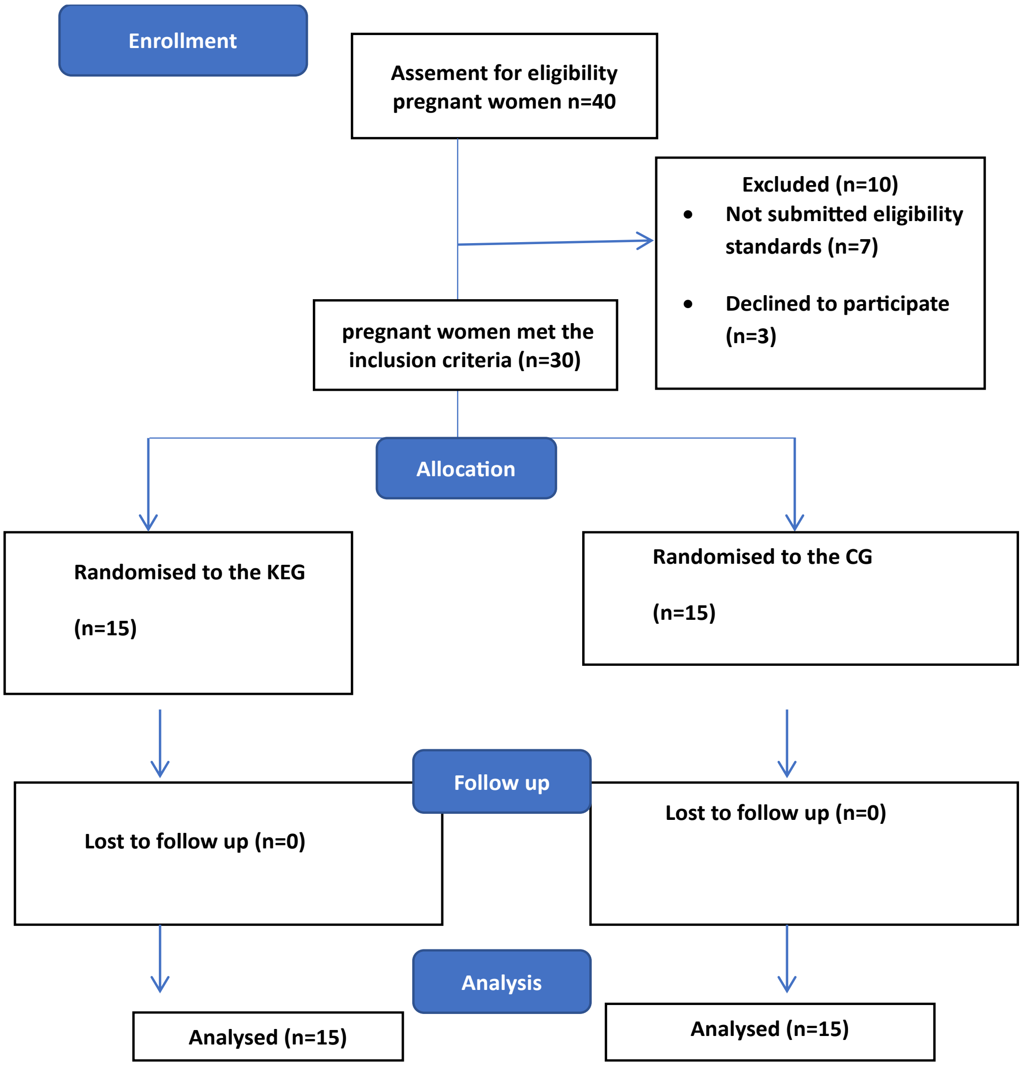

Fig 1: Flow Chart of the study populations

3.1.General characteristics of participants

Non-significant differences (p>0.05) were observed between 2 groups (KEG and CG), related to age:(mean±SD) for KEG group is 23.2 ±1.47 while for CG is 23.2 ± 1.47 with p-value =1, BMI: (mean±SD) for KEG is 30.82 ± 0.73 while for CG is 30.37± 0.69 with p-value = 0.757 and Week gestation: (mean±SD) for KEG is 30.13 ± 2.1 while for CG is 31.35 ± 1.29 with p-value = 0.067.

3.2. participants performance

between group analysis: As shown in Table (1) there was no statistically significant difference in performance (p>0.05) before treatment between both groups at 28 WG, with a Significant difference (p<0.05) between both groups at 32 WG and 2 weeks postpartum.

Table (1): Allotting of performance between both groups at pre and post-intervention :

Time	**WG 28 (Pre-intervention)**		**WG 32 (Post 1)**		**2 weeks postpartum (Post 2)**	
	KEG	**CG**	**KEG**	**CG**	**KEG**	**CG**
Mean	80.330	78.870	96.920	77.590	95.670	80.600
± SD	8.524	5.792	2.167	3.032	3.773	5.054
Mean difference	-1.460		-19.330		-15.070	
P-value	0.586		< 0.001		< 0.001	
Level of significance	Non-significant		Significant		Significant	

Within-group analysis: as shown in Table 2 there were statistically significant differences (p<0.05) in KEG and CG performance before, after treatment, and 2 weeks postpartum

According to the post Hoc test, there was a statistically significant difference in KEG performance between pre vs post 1 and pre vs post 2 (p<0.05). There was no statistically significant difference in KEG between post 1 and post 2 (p>0.05). There was a statistically significant difference in CG performance between post 1 vs post 2 (P<0.05). There was no statistically significant difference in CG performance between pre vs post 1 and pre vs post 2.

Table (2): Allotting of performance within both groups at pre and post-intervention:

	KEG			CG		
	WG 28 (Pre-intervention)	**WG 32 (Post 1)**	**2weeks postpartum (Post 2)**	**WG 28 (Pre-intervention)**	**WG 32 (Post1)**	**2 weeks postpartum (Post 2)**
Mean	80.330	96.920	95.670	78.870	77.590	80.600
+ S.D	8.524	2.167	3.773	5.792	3.032	5.054
F-value	87.445			6.424		
P-value	< 0.001			0.005		
Level of significance	significant			significant		
Post Hoc test	Mean difference	% of difference	P-value (Sig)	Mean difference	% of difference	P-value (Sig)
Pre vs Post (1)	16.590	20.7%	< 0.001	-1.280	-1.6%	0.998
Pre vs Post (2)	15.340	19.1%	< 0.001	1.730	2.2%	0.394
Post (1) vs Post (2)	-1.250	-1.3%	0.248	3.010	3.9%	0.001

Performance in the balance checkboard is the average of 4 outcomes (FAD, BAD, LAD, and RAD)

3.3. Participants postural stability (Mini-BESTest)

between group analysis: As shown in Table (3) there was no statistically significant difference in postural stability (p>0.05) before treatment between both groups at 28 WG, with a Significant difference (p<0.05) between both groups at 32 WG and 2 weeks postpartum.

Table (3): Allotting of postural stability between both groups at pre and post-intervention:

Time	WG 28 (Pre-intervention)		WG 32 (Post1)		2 weeks postpartum (Post2)	
	KEG	**CG**	**KEG**	**CG**	**KEG**	**CG**
Mean	19.930	18.800	27.130	19.990	27.400	21.370
± SD	2.890	2.833	1.125	2.752	0.737	3.048
Mean difference	-1.130		-7.140		-6.030	
p-value	0.287		< 0.001		< 0.001	
Level of significance	Non-significant		Significant		Significant	

Within-group analysis: as shown in Table 4 there were statistically significant differences (p<0.05) in KEG and CG postural stability before, after treatment, and 2 weeks postpartum

According to the post Hoc test, there was a statistically significant difference in KEG postural stability between pre vs post 1 and pre vs post 2 (p<0.05). There was no statistically significant difference in KEG between post 1 and post 2 (p>0.05). There was a statistically significant difference in CG between pre vs post-2 and post 1 vs post 2

(P<0.05). There was no statistically significant difference in CG between pre vs post-1 (p>0.05)

Table (4): Allotting of postural stability within both groups at pre and post-intervention:

	kEG			CG		
	WG 28 (Pre-intervention)	**WG 32 (Post1)**	**2 weeks postpartum (Post2)**	**WG 28 (Pre-intervention)**	**WG 32 (Post1)**	**2 weeks postpartum (Post 2)**
Mean	19.930	27.130	27.400	18.800	19.990	21.370
+ S.D	2.890	1.125	0.737	2.833	2.752	3.048
F-value	155.853			22.450		
P-value	< 0.001			< 0.001		
Level of significance	significant			significant		
Post Hoc test	Mean difference	% of difference	P-value (Sig)	Mean difference	% of difference	P-value (Sig)
Pre vs Post (1)	7.200	36.1%	< 0.001	1.190	6.3%	0.041
Pre vs Post (2)	7.470	37.5%	< 0.001	2.570	13.7%	< 0.001
Post (1) vs Post (2)	0.270	1.0%	0.998	1.380	6.9%	<0.001

4. DISCUSSION

The study documented a significant increase in performance and postural stability among participants in the KEG group during the intra-group analysis. A significant improvement was noted over the period from 28 weeks gestation to 32 weeks gestation, as well as from 28 weeks gestation to 2 weeks postpartum (p < 0.05). No statistically significant difference was found in KEG performance and postural stability from 32 weeks gestation to 2 weeks postpartum (p>0.05). Upon doing a comparative analysis of the two groups before therapy, it was determined that there existed no statistically significant difference in terms of performance or postural stability (p>0.05). A statistically significant d difference (p<0.05) was noted between the two cohorts at 32 weeks gestation as well as two weeks postpartum. The control group had a significant decline in proprioceptive ability during weeks 32 and 2 after childbirth, in comparison to week 28. The outcomes of this study are in accordance with prior research, which has consistently shown that pregnant women in the third-trimester display enhanced postural stability and performance in comparison to those in the second trimester. They also noticed a further decline in postural stability throughout pregnancy [7, 9, 24, 27]. El-Shamy et al conducted independent studies wherein they discovered a noteworthy impact of postural stability exercises on postural stability when administered with postural training [22, 7]. The current investigation employed a rehabilitation program that incorporated the utilization of a pezzi ball as a means to enhance proprioceptive control of the joints. The primary focus of this inquiry is to investigate the impact of the central nervous system (CNS) on motor activities, as shown by previous research [28,29]. The activation of proprioceptive circuits in the central nervous system has been observed by the use of Pezzi balls [27], which may stimulate cutaneous mechanoreceptors. Proprioceptive neuromuscular facilitation (PNF) is a therapeutic approach that is grounded in the fundamental principles of muscle contraction, extension, and the stimulation of muscle chains (30).

The study's findings may be attributed to the exercise ball's capacity to enhance balance, muscle tone, and spatial awareness, as demonstrated by its potential. The motor learning hypothesis offers a theoretical framework to account for the observed improvements in patients undergoing pezzi ball rehabilitation, emphasizing the identification of augmented cortical synapses and modifications in synaptic cortical connections [28]. The increase in participants' balance can be related to the augmentation in the functioning of joint mechanoreceptors [30]., ankle-foot articular receptors, and the connections between receptors in the peripheral nervous system and circuits that are responsible for regulating postural stability [7]. Another potential argument to be addressed is the modification of joint afferent receptors, which might potentially affect the musculature's capacity to enhance joint stability through the process of co-contraction involving antagonistic and synergistic muscles [31].

The maintenance of postural equilibrium in the postpartum woman two weeks after childbirth, as shown during the KEG follow-up, may be related to the persistence of repetitive movements as central directives. The preservation of joint proprioceptors may be influenced by the retention of information [7]. The potential influence of providing a brochure on routine care to participants in the control group on the observed improvement in performance levels at the two-week postpartum evaluation should be considered.

However, our research findings diverge from the study conducted by Wojtys et al. [32], which claimed that there is insufficient evidence to support the efficacy of proprioception exercises in improving postural stability.

5- CONCLUSION

Short-term kinaesthetic training increases postural stability and performance during pregnancy and at the 2-week postpartum follow-up.

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Authors' contributions

The authors contributed significantly to the study's idea and design, data collecting, and data analysis. They also helped to draft the manuscript or critically review it for significant intellectual content. The final manuscript has been read and approved by all writers.

Conflict of interest

There are no competing interests, according to the authors.

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