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# The impact of the corrective and stability exercises program on the quality of basic movement patterns among dance students

MARTA SKOTNICKA, KRZYSZTOF KARPOWICZ, SYLWIA BARTKOWIAK, RYSZARD STRZELCZYK

**Abstract**
Introduction. **Based on the kinetic chain model, in which the body is a linked system of interdependent and working in a proximal to distal order segments, the main task of the core is to stabilize the kinetic chain during functional movements. Poor core stability and muscle imbalance are factors that may contribute to injuries. By detecting imbalances, deficits and asymmetries in basic movement patterns, there is a tool which can provide the basis for the implementation of preventive strategies.** Aim of Study. **The main purpose of the present study is to verify the effectiveness of the corrective and stability exercises program on the quality of basic movement patterns among dance students.** Material and Methods. **The study was perform on 18 female students of first year of the Dance in physical culture from University of Physical Education in Poznan, Poland, who were divided into 2 groups: intervention (n = 9) and control (n = 9). In both groups, were carried out pre- and post-test. The quality of basic movement patterns was evaluated by the Functional Movement Screen, consisted of seven tests: deep squat, hurdle step, in-line lunge, shoulder mobility, active straight leg raise, trunk stability push-up, rotary stability. In the intervention group was introduced the program of corrective exercises based on the obtained results enriched with core stability exercises. After 12-week training program, the quality of basic movement patterns were assessed again in both groups.** Results. **The research found out that at the pre-test there was no significant differences between both groups. However, the groups differed significantly ($p < 0.05$) at post-test in terms of the overall result of the FMS and 2 tests: deep squat and in-line lunge. Significant posttraining changes were noted for the intervention group in the overall FMS scores and 4 tests: deep squat, hurdle step, in-line lunge, trunk stability push-up. Significant changes were also found in the control group in the overall FMS results and in the deep squat test.** Conclusions. **The identification of the "weakest links" of kinetic chain, integrated with properly planned and conducted corrective exercises, enriched with core stability exercises may positively impact on the quality of basic movement patterns, which seems to be the starting point for determining the possibility of used tool to prevent injuries.**

**KEYWORDS: Functional Movement Screen, FMS, intervention program, training, core stability.**

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Corresponding author: skotnicka.marta15@gmail.com

*Poznan University of Physical Education, Faculty of Physical Education, Sport & Rehabilitation, Department of the Theory of Sport, Poznań, Poland*

## Introduction

All individuals pass through the same levels of the developmental movement progression, starting from the control of the head and neck, through rolling, creeping, crawling, kneeling, squatting, standing, stepping, walking, up to jogging. They have the same foundations of movement [1-3]. The proper stability is a prerequisite for the purchase of movement patterns during the early stages of growth and development. This also applies to the motor behavior for the rest of life [3].

Proper core stability prevents injuries and relieves lower back pain, provides proximal stability for distal mobility [4]. Stable pelvis and trunk mediate the transmission of forces generated by the lower extremities towards the upper extremities [5]. The main task of the core is to stabilize the kinetic chain during functional movements [4]. All stabilizers should be balanced because the weakness of the link leads to compensatory movements, consequently imbalances in the global stability chain. It is also suggested that the first step in any rehabilitation program should be corrective stability training. Focusing on strengthening exercises at the beginning, without taking into account poor stability, may reinforce faulty movement patterns [3, 4]. Following poor biomechanics, increased risk of injury is possible [1].

Based on the kinetic chain model, in which the body is a linked system of interdependent and working in a proximal to distal order segments, there was developed a tool used to assess the movement competency – quality of basic movement patterns – Functional Movement Screen (FMS). The battery of 7 tests evaluates basic mobility, stability and balance between these components. It is designed to allow for observe limitations, asymmetries, imbalances and weaknesses by placing an individual in extreme positions [1]. Although its role in the evaluation of sport performance is limited [6, 7], it seems to predict risk of injury [8-10].

The dance compared with other physical activities is associated with high risk of injury and its incidence, according to research of different authors, ranges from 75% to 97% [11] or from 42% to 97% [12]. Considering students of the contemporary dance, even 89% suffers injuries during the academic year [13]. Poor core stability and muscle imbalance are factors that may contribute to them among dancers [12, 14].

By detecting imbalances, deficits and asymmetries, FMS can provide the basis for the implementation of preventive strategies [1]. The starting point for determining the tool's ability to prevent injuries is first to examine whether under the influence of various exercises the quality of basic movement patterns (measured by FMS) can be improved and which ones are the most effective.

The number of reports on this subject is very small. The authors found only 5 studies that have evaluated the exercise programs influence on the FMS result [15-19]. Research are varied in terms of the sample, the types of the intervention programs and the results of these investigations. To our knowledge, no investigation have been conducted among dancers (dance students) who may be at risk, because of the nature of this activity and the future profession. We found only 2 studies which have introduced corrective exercises based on the FMS score. Furthermore, no estimating mentioned intervention enriched with core stability exercises has been discovered.

In light of the above, the main objective of the present study is to verify the effectiveness of the corrective and stability exercises program on the quality of basic movement patterns evaluated by the FMS among dance students. This is also associated with tool's ability to detecting changes in movement patterns after specific actions.

## Materials and Methods

*Subjects*

A quasi-experimental design was used for this study and was conducted on 18 female students of first year of the Dance in physical culture from University of Physical Education in Poznan, Poland. Subjects were divided into two groups: intervention (n = 9) and control (n = 9). Somatic characteristics of all participants have been shown in Table 1. The mean ± SD age, body height, body mass, and BMI of intervention group were 22.02 ± 2.26; 165.89 ± 5.33; 58.43 ± 4.77; 21.22 ± 1.30, respectively. In control group: 21.72 ± 1.33; 166.78 ± 5.76; 59.26 ± 7.70; 21.23 ± 1.63, respectively. All subjects gave informed consent to participate in this study before any data collection and were free from any current musculoskeletal injuries or pain at the commencement of the study, during testing and intervention program.

The research presented in this paper was conducted in accordance with the ethical standards of the Declaration of Helsinki (Ethical Principles for Research Involving Human Subjects). The study was approved by the local Research Ethics Committee (Karol Marcinkowski Medical University in Poznan, Poland).

**Table 1.** Somatic characteristics of the intervention group and the control group

| Group | Age (years) | Body height (cm) | Body mass (kg) | BMI (kg/m²) |
|---|---|---|---|---|
| Intervention | 22.02 ± 2.26 | 165.89 ± 5.33 | 58.43 ± 4.77 | 21.22 ± 1.30 |
| Control | 21.72 ± 1.33 | 166.78 ± 5.76 | 59.26 ± 7.70 | 21.23 ± 1.63 |

*Functional Movement Screen*

FMS is used to evaluate the quality of basic (fundamental and functional) movement patterns. It consists of 7 tests: deep squat, hurdle step, in-line lunge, shoulder mobility, active straight leg raise, trunk stability push-up, rotary stability. The scores range from 0 to 3 (0 – pain during the movement; 1 – an individual is unable to complete the movement pattern or is unable to assume the position; 2 – movement pattern with any compensation; 3 – correct movement pattern without compensations). There are also 3 clearing tests which only consider pain, rated as positive or negative (active scapular stability, spinal extension, spinal flexion). On the FMS individual can attain up to 21 points [20].

*Procedures*

In both groups was carried out a pre-test (consisting of the evaluation of the quality of basic movement patterns, measurement of body height, body mass, BMI) and posttest (re-assessed quality of movement patterns).

The assessment of movement patterns was conducted in accordance with previously published guidelines [20]. Subjects were worn clothing that not limited movements, while adhered to the body in order to evaluate movement patterns with greater accuracy. There was no warm-up prior to the test and only standardized verbal instructions were used, no specific cues were given. The FMS test kit was used. Each participant was given 3 attempts on each test. The best repetition was recorded. In the case when there was an asymmetry in the presented pattern a student was received lower score. In addition, any compensations, deviations or comments were recorded, useful when designing an intervention program. In order to recording results and comments the FMS score sheet was utilized.

Between testing sessions in the intervention group introduced corrective exercises program, based on the result obtained in the FMS test, enriched with core stability exercises. Supervised exercise program lasted 12 weeks. Training sessions were held once a week for 1.5 hours in the buildings of the University of Physical Education, equipped with mirrors and: mats, Swiss balls, small balls, gym sticks, sensory discs, aerobic steps, rubber expanders. Some of the corrective exercises have been drawn from the available research [2, 19, 21]. The remaining exercises were based on the experience of the authors.

Given the direction of the influence, the following exercises were used:

Deep squat
1) Half kneeling ankle dorsiflexion stretch
2) Standing rectus stretch
3) Toe touch progression
4) Wall squats
   - with Swiss ball
   - with gym stick above head
   - with sensor discs under feet
   - with small ball

Hurdle step
1) stride with hip external rotation
2) stride with spinal rotation
3) Incline Mountain Climbers
4) Supine bridge
   - with arms on the floor/crossed on the chest
   - with alternate knee flexion
   - with alternate leg extension
   - with sensory disc under foot
5) Flexion, extension, adduction and abduction leg movement while single leg standing
   - with sensory disc

In-line lunge
1) Leg lock bridge
2) In-line lunge
   - with/without sensory discs
3) Lunge
   - with/without sensory discs

Shoulder mobility
1) Trunk rotation with shoulder internal/external
2) Wall sit with shoulder press

Active straight leg raise
1) Single leg lowering
2) Stretching exercises

Trunk stability push-up
1) Incline push-up
2) Walk out to push-up position
3) Push-up with bent knees
4) Push-up
5) Push-up walk out

Rotary stability
1) Bilateral hip flexed rotation
2) Hip flexed torso rotation
3) Rolling progression

Core stability (Swiss ball exercises only)
1) Swiss ball crunches
2) Prone bridge on Swiss ball
3) Swiss ball knee tuck
4) Prone bridge on Swiss ball with feet on sensory disc
5) Swiss ball supine pelvic rotation with legs supported
6) Pelvic bridge trunk rotation with shoulders flexed on Swiss ball
7) Pelvic bridge alternating knee extension with shoulders flexed on Swiss ball
8) Swiss ball push-up
9) Swiss ball curl-up

Some of the aforementioned exercises have had more than one plane of impact. After the warm-up isometric exercises were performing, eg. various kinds of planks. In addition, the end part was dedicated to stretching exercises. The circuit training was used (usually consisted of 9-12 exercises: 3 sets, 1 minute per station; 15 seconds between repetitions; 2 minutes between sets). Each participant knew her results. Attention was paid to correct movement (movement quality) and individualization. Every move had to be carried out in a controlled manner. More difficult exercises have been implemented when easier were mastered. This also referred to the arrangement of the upper extremities, for example in the supine position. Where it has been possible, the fulcrum was reduced.

*Statistical analysis*

For statistical calculates, the Statistica software package, version 12.0, was used. In order to determine the significance of differences between groups, the independent samples t-test was used. To calculate the significance of differences between the periods of testing, the dependent t-test for paired samples was used. Statistical significance was set at the level of $p < 0.05$. Basic statistical methods (arithmetic mean, standard deviation) were used for the analysis of the following data: age, body height, body mass, BMI.

## Results

The first step was to analyze the significance of results differences between groups. There were significant differences in overall FMS scores between groups at post-test (p = 0.038534), despite the initial lack of differences (p = 0.139726). The average FMS results (± SD) at the initial test period totaled 14.33 ± 1.41 points in the intervention group and 15.22 ± 0.97 points in the control group. At the final test period mentioned groups received 17.67 ± 1.73 points and 16.22 ± 0.83 points, respectively (Table 2).

There were no significant differences between the intervention and control groups at the initial period of the study for any test. Both of them obtained on average, the lowest results (± SD) on the deep squat (the intervention group: 1.33 ± 0.50 points; the control group: 1.56 ± 0.53 points) and the trunk stability push-up tests (the intervention group: 1.33 ± 0.71 points; the control group: 1.56 ± 0.73 points). The highest results (± SD) in the intervention and control groups were noticed on the shoulder mobility (2.89 ± 0.33 and 2.78 ± 0.44 points, respectively) and the active straight leg raise tests (2.78 ± 0.44 and 3.00 ± 0 points, respectively). The results are presented in Table 2.

At the final screen, statistically significant differences between the groups were found on the deep squat (p = 0.048286) and the in-line lunge (p = 0.022294). The shoulder mobility and the active straight leg raise were found to be the best scored tests in the intervention group (3.00 ± 0 and 2.89 ± 0.33 points, respectively) and control group (3.00 ± 0 points on both tests). However, the trunk stability push-up (the intervention group: 2.11 ± 0.93 points; the control group: 1.89 ± 0.78 points), the rotary stability (the intervention group: 2.11 ± 0.33 points; the control group: 2.00 ± 0 points), and in-line lunge in the control group (2.00 ± 0 points) were found to be the lowest graded tests (Table 2).

**Table 2.** Significance of differences between mean results (±SD) obtained in subsequent testing periods between the groups

| | Pre-test | | Post-test | | Significance of differences | |
|---|---|---|---|---|---|---|
| | Intervention group | Control group | Intervention group | Control group | Pre-test | Post-test |
| Overall score | 14.33 ± 1.41 | 15.22 ± 0.97 | 17.67 ± 1.73 | 16.22 ± 0.83 | 0.139726 | 0.038534 |
| Deep squat | 1.33 ± 0,50 | 1.56 ± 0.53 | 2.56 ± 0.53 | 2.11 ± 0.33 | 0.372422 | 0.048286 |
| Hurdle step | 2.00 ± 0 | 2.22 ± 0.44 | 2.56 ± 0.53 | 2.22 ± 0.44 | 0.150069 | 0.164949 |
| In-line lunge | 2.00 ± 0 | 2.11 ± 0,33 | 2.44 ± 0.53 | 2.00 ± 0 | 0.332195 | 0.022294 |
| Shoulder mobility | 2.89 ± 0.33 | 2.78 ± 0.44 | 3.00 ± 0 | 3.00 ± 0 | 0.554946 | – |
| Active straight leg raise | 2.78 ± 0.44 | 3.00 ± 0 | 2.89 ± 0,33 | 3.00 ± 0 | 0.150069 | 0.332195 |
| Trunk stability push-up | 1.33 ± 0.71 | 1.56 ± 0.73 | 2.11 ± 0.93 | 1.89 ± 0.78 | 0.520147 | 0.590289 |
| Rotary stability | 2.00 ± 0 | 2.00 ± 0 | 2.11 ± 0.33 | 2.00 ± 0 | – | 0.332195 |

Values are mean ± SD

* significant differences at p ≤ 0.05

**Table 3.** Mean differences (±SD) of the individual tests results and the overall scores between subsequent testing periods for the groups with their statistical significance

| | Intervention group | | Control group | |
|---|---|---|---|---|
| | Post-Pre | p – value | Post-Pre | p – value |
| Overall score | 3.33 ± 1,00 | 0.000008 | 1.00 ± 0.50 | 0.000323 |
| Deep squat | 1.22 ± 0.67 | 0.000574 | 0.56 ± 0.53 | 0.013349 |
| Hurdle step | 0.56 ± 0.53 | 0.013349 | 0.00 | – |
| In-line lunge | 0.44 ± 0,53 | 0.035265 | –0.11 ± 0.33 | 0.346594 |
| Shoulder mobility | 0.11 ± 0.33 | 0.346594 | 0.22 ± 0.44 | 0.169020 |
| Active straight leg raise | 0.11 ± 0,33 | 0.346594 | 0.00 | – |
| Trunk stability push-up | 0.78 ± 0,83 | 0.023198 | 0.33 ± 0.50 | 0.080516 |
| Rotary stability | 0.11 ± 0,33 | 0.346594 | 0.00 | – |

* significant differences at $p \leq 0.05$

In regards to the differences within the groups, both significantly improved their overall FMS results. The increase for the intervention group was higher (on average 3.33 ± 1.00 points; p = 0.000008) in comparison with the control group (on average 1.00 ± 0.50 points; p = 0.000323). The results of all 7 tests improved in the intervention group after the training program. However, the statistically significant posttraining changes were noted on 4 of them in mentioned subjects (mean ± SD; p – value): the deep squat (1.22 ± 0.67 points; p = 0.000574), the hurdle step (0.56 ± 0.53 points; p = 0.013349), the trunk stability push-up (0.78 ± 0.83 points; p = 0.023198) and the in-line lunge (0.44 ± 0.53 points; p = 0.035265). Interestingly, the control group improved scores of the deep squat test (on average 0.56 ± 0.53 points). Thereby, it was a significant change (p = 0.013349). However, the hurdle step, active straight leg raise and rotary stability tests results remained the same at the post-test. Furthermore, a decrease in scores of the in-line lunge was noticed (Table 3).

## Discussion

The main purpose of this study was to verify the effectiveness of the corrective and stability exercises program on the quality of basic movement patterns evaluated by the FMS among dance students. It should be mentioned that to the present, the number of research verifying the impact of the applied exercise programs using the FMS test, is limited, and only 5 were found [15-19]. Most available studies are focused exclusively on male groups [15-17, 19], or mixed group [18]. Furthermore, varied samples were involved: firefighters [16, 17], middle-aged adults [18], mixed martial arts athletes [15], professional football players [19]. This study is probably the first, in which female dance students were engaged.

At the initial test period, there were no significant differences between the intervention and control groups. However, post-test highlighted that overall FMS scores of both groups were significantly different. Statistically significant differences between the groups were also found in 2 tests: deep squat and in-line lunge. In the light of the initial lack of differences, implemented intervention program could be affected by obtained results. It is suggested that the FMS can provide the basis for the implementation of corrective strategies by detecting imbalances, deficits and asymmetries [1]. Our findings seems to uphold this.

The authors of the another study, came to the similar conclusions [15]. Based on the FMS scores, some corrective exercises were implemented. The intervention and the control groups differed significantly at the final testing. Mentioned study was the only found, which took into account a control group and corrective exercises. However, a deeper comparisons does not seem to be possible, not only because of the different nature of the activity (dance compared to mixed martial arts), but due to the presentation of results. Overall FMS scores were recognized in the form of a threshold value (≤14 points or >14 points), which may be associated with an increased risk of injury [8].

An off-season intervention program among professional football players, where the FMS scores were also the basis while designing corrective exercises, had a positive effect in improving aforementioned results. As in the study above, the statistical significance was determined by taking into account mentioned threshold value. There was no control group, thus the interpretation of outcomes may be impeded.

The dance students from the intervention group significantly improved their overall FMS scores, on average of 3.33 ± 1.00 points. It appears that yoga exercises can also affect positively on the quality of basic movement patterns [17]. Firefighters, incorporated to the mentioned study, significantly improved their overall FMS scores, on average of 3.30 ± 2.32 points. These findings were similar to found among dance students. At the first testing, firefighters received on average 13.25 ± 2.25 points, while at the second 16.55 ± 2.13 points. However, a weak point of the research was the lack of a control group. Comparing the mean overall FMS results, the intervention group of female dance students achieved higher scores at the pre- and post-test than firefighters (14.33 ± 1.41 points and 17.67 ± 1.73 points, respectively). In turn, the control group received higher scores at the pre-test (15.22 ± 0.97 points), but lower scores at the post-test (16.22 ± 0.83 points), compared with firefighters.

The subject of another investigation [16] were also firefighters, who were divided into 3 groups, and obtained at the initial and final testing period: 13.1 ± 2.7 and 13.5 ± 2.3 (intervention 1); 12.8 ± 1.7 and 13.1 ± 1.8 (intervention 2) 13.3 ± 2.5 and 13.0 ± 2.4 (control), respectively. The dance students also in this case were rated higher. Perhaps, the relatively good quality of basic movement patterns among female dance students is related to the characteristics of their activity, where the movement quality plays an important role. However, the fundamental difference between the studies was the type of entered variable. As indicated by the authors, both the quantity and quality have been emphasized in the intervention group 1 (whole-body coordination, mobility and neuromuscular control), and only the quantity in the intervention group 2 (strength, power, aerobic capacity). Most likely, the emphasis on quantity, especially in the intervention group 1, was the reason why the outcomes did not demonstrate any significant change, both between groups and between the testing periods.

Given the above results, the emphasis on quantitative component does not appear to affect the quality of the basic movement patterns. On the other hand, the training program created on the FMS basis, seems to improve strength and flexibility, assessed by commonly used quantitative tests [22]. Therefore, an approach in which good quality of basic movement patterns should be a prerequisite for implementation directory of strength and conditioning training [20, 21] could be justified.

Furthermore, when compared the effects of regular strength training and functional training among middle-aged adults, both intervention groups significantly improved their FMS scores, but the groups did not differ significantly. The strength training group obtained at the pre- and post-test 11.6 ± 1.66 and 13.2 ± 1.69 points, respectively. The functional group received 11.4 ± 2.00 and 12.7 ± 1.62 points, respectively [18]. It indicates that the outcomes were much lower than for dance students, and were associated with greater injury risk, according to the threshold value (≤14 and >14 points). It may be caused by age of participants (over 50 years), which is negatively correlated with the scores of the FMS test [23]. Also improvement of the quality of basic movement patterns was lower (an average of 1.6 points in the regular strength training group and 1.3 points in the functional group) than among dancers who received an intervention (on average of 3.33 points). In addition, the study also did not include a control group as well as some previously mentioned [17, 19]. This seems to be important from the point of view accurately determine the effectiveness of the applied training program.

In available research did not reported how the used of training has affected the individual results of FMS test, despite the fact that not only the threshold value, but also components of the test may be associated with the risk of injury [24, 25]. At the initial testing students of both groups obtained the lowest results on the deep squat and the trunk stability push-up. The highest results were noticed on the shoulder mobility and the active straight leg raise. Similar results, which seems to be caused by greater flexibility and range of motion among women, as well as lower level of muscle strength compared to men, were also found in the another study [26]. In addition, high scores on the active straight leg raise and shoulder mobility are probably the result of undertaken physical activity (dance).

In regards to the differences within the groups, the intervention group significantly improved the overall FMS results, and the scores on the deep squat, hurdle step, in-line lunge and trunk stability push-up. Interestingly, our findings also suggested significant (but lower than in the intervention group) changes among the control group in overall FMS scores and on the deep squat. Most likely, the reason for this situation was an additional physical activity. It should be also taken into consideration that the subjects were on the first year of studies. Perhaps, precisely this dance activity could, to a certain extent contribute to the improvement of results. However, because of taking into account the control group when designing this study, which is its strong point, it turned out that the two groups differed significantly both in terms of the overall FMS and the deep squat results. In addition, the groups were also significantly different on the in-line lung at the post-test. An important aspect that needs to be clarified is whether the subjects should know their results and objectives of the FMS test. In the case of the verification of effectiveness of any training on the FMS results, perhaps the lack of information about the results [16] is justified. However, if the objective is to verify the impact of training, created based on the outcomes obtained on the FMS, we believe that by increasing awareness, and thus active inclusion of individuals in the process of improving the quality of basic movement patterns, actions are likely to be effective. Also, in real-life conditions, we cannot turn off the motivational factors that may result from the knowledge about ourselves.

Unfortunately, no report has been found on the effect of core stability exercises on the FMS results. It is known, however, that may affect the reduce injuries when they are created based on test FMS [27]. Also with regard to the dancers, their importance recognizes primarily in the effective protection of the structures of the musculoskeletal system from injuries [28]. In addition, the overall FMS scores and core strength are positively correlated [29], probably because of the ability of the core to stabilize the kinetic chain during functional movements [4]. Therefore, the combination of the core stability exercises with the corrective exercises based on the FMS results, appears to be justified among dancers. In addition, for future studies it is also recommended to present a set of exercises which was used, because only in one found study the training program was outlined [18]. Through observation, which exercises are most often reproduced, comparing with test results, perhaps one could estimate which seems to be most effective, leading to the unification of the training program.

However, despite the identified statistically significant differences between the intervention group and the control group, as well as the differences between the terms of testing, the sample size is a certain limitation. The number of subjects was small, since the studies had a pilot character, designed to justify taking the present research issue. In future studies, it is recommended to enable larger groups, also from other areas of physical activity. Further research are required to determine whether or not number of injuries will reduced after an intervention program.

## Conclusions

Despite the initial lack of significant differences between the experimental and control group, there were statistically significant at the final testing period in some movement patterns. Although, certain improvement in the control group was noticed, however the intervention group demonstrated greater changes, also in greater number of movement patterns compared to the initial test period. In light of the above, the identification of the "weakest links" of kinetic chain, integrated with properly planned and conducted corrective exercises, enriched with core stability exercises may positively impact on the quality of basic movement patterns.

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