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DIFFERENCES IN LOWER LIMB STABILITY BETWEEN ATHLETIC AND NON-ATHLETIC YOUNG WOMEN[1]

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Abstract: The purpose of the study is to identify the effects of performance sports practice by young women on the stability of the lower limbs. 19 female performance athletes (21.67±3.33 years, 171.5±4.82 cm, 68.86±7.70 kg) and 21 untrained girls (21.62±2.42 years, 163.3±5.96 cm, 57.26±7.33 kg) were measured.

Stability was determined with the MFT Challenge Disc Bluetooth 2.0. Two pre-set software tests (unilateral and bilateral) were applied, each performed with free arms and the hands on the hips.

Applying One-way Anova, significant differences were observed between the two groups regarding unilateral balance ($F_{(7,147)}$=9.702, p<0.0001), as well as bilateral balance ($F_{(3,76)}$=5.459, p=0.0019). The comparison of the results between them showed that the female athletes had worse results in bilateral and lateral measurement. Untrained females obtained the best unilateral result on the left side with hands on hips (2.20±0.60). Bilaterally, the same group obtained a better result than female athletes when testing with hands on the hip (2.20±0.60).

The differences between the two sides show stability for each group. Our study reveals a better stability of untrained girls compared to athletes, an aspect that can be clarified by further investigations.

Keywords: Balance, posture, performance, sport, MFT testing

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Introduction

The assessment of postural control is applied by many specialists to determine the risk of injury and the recovery rate, among the most used tests is the Y-Balance (YBT) (Mohammadi, et al., 2023; Trofin, et al., 2024; Trofin, et al., 2023). Some specialists have emphasized the importance of postural balance, it is effective in reducing the injury rate of athletes (Zemková, 2014), as well as the negative consequences on the athlete's physical condition. Monitoring the postural balance of performance athletes is very important, because the continuous practice of the discipline can establish imbalances specific to it, an aspect that could affect their performance (Gobbi, et al., 2013).

The MFT Challenge Disc is another device often used to determine the stability and coordination of the lower limbs, this one being more stable and safe (Promsri, 2022; Mayer, et al., 2022; Rühlemann, et al., 2020). The MFT Disc is recommended for the first phase of recovery after lower limb injuries (Promsri, 2022). For example, Andreeva et al. (2021) claim that practicing any type of sport is associated with increased postural control, especially in bipodal position. Also, the same conclusion was brought into consideration by Mocanu et al. (2022), who claim that students who play sports at a performance level have a much more developed stability than those who do not play sports. Compared to the unilateral assessment, body swing parameters can be used to analyze the stabilization capacity in static conditions in the situation of unilateral body weight distribution, an aspect that is encountered in sports activities (Trajković, et al., 2022).

Unilateral stability testing is recommended for clinicians as an optimal tool to assess the risk of injury due to falls (Kozinc, et al., 2020). It also has several applications in both clinical and sports medicine settings (Riemann & Schmitz, 2012). The use of a test involving a unilateral position is found in several studies, Trajković et al. (2022) applied it due to its similarity to movements in sports that require balance or balancing on one leg, as well as the fact that athletes must have a well-developed postural stability capacity, this aspect before controlling any action motor.

Glofcheskie and Brown (2017) determined that greater postural control of the trunk, less angular displacement of the lumbar spine, greater muscle activation capacity, especially trunk muscles, in response to unexpected perturbations were found in athletes, compared to non-practitioners. It is claimed that stability is not influenced by gender, but some studies indicate that women have better postural stability, this being related to early physical and psychological maturation (Butz, et al., 2015). Other specialists indicate that during childhood postural stability is better controlled by girls, while in adulthood they tend to have poorer results in postural control compared to boys (Schedler, et al., 2019; Błaszczyk, et al., 2014). Another factor that tends to influence postural stability in women involves the development of proprioception and vestibular functions (Smith, et al., 2012).

Stability is correlated with performance in cricket, cycling, athletics and team sports (baseball, football, hockey, netball, tennis). Neuromuscular control of postural and core stability contributes to more efficient functional movements specific to certain sports (Zemková & Zapletalová, 2022). Paillard T. (2019) concluded that athletes who reach a high level of performance show the best postural results, both in sport-specific and non-specific conditions. Whereas, Zemková E. (2014) concludes that better results were recorded by the athletes during the tasks specific to the practicing sports discipline.

Hrysomallis C. (2011) argues that balance is associated with performance level. The best postural control was found among gymnasts, followed by soccer players, swimmers and basketball players. Differences were found between rifle and golf athletes based on their performance level, with the less experienced having less postural control compared to the more experienced (Hrysomallis, 2011).

Marques et al. (2017) and Streckmann et al. (2014) found that endurance training is effective in producing positive changes in postural control and balance abilities. A much more developed balance was found in young female handball players (16-19 years) compared to those over 20 years of age, with the latter achieving the highest scores on the MFT Challenge disc test. The youngest also recorded lower stability scores when testing unilaterally with the dominant leg, which denotes a much more developed balance (Mayer, et al., 2022). A low level of stability can lead to major knee injuries in sports that require rapid changes of direction and movement, such as handball, hockey, soccer, basketball, badminton, softball, squash, table tennis, tennis and volleyball (Zemková, 2011).

The physiological mechanisms that can affect balance after a physical exercise, according to some specialists, are: the resulting state of fatigue, hyperventilation, damage to the functions of mechanoreceptors, proprioceptors, damage to the functions of the vestibular apparatus and the visual receptor, muscle injuries, dehydration, hyperthermia and dizziness (Zemková, 2011).

One research pointed out that at an initial assessment, endurance athletes performed superiorly in the stability test compared to non-exercisers, who had superior postural control. It is also claimed that due to the physical, strength and proprioceptive exercise routine performed by the athletes, the values obtained by them are better compared to non-practitioners (Seidel, et al., 2017).

Methods

Our study aimed to measure the stability of the lower body for 19 handball players and 21 girls, the last of them not involved in the systematic practice of a sport at the time of the examination. Thus, the subjects were divided into trained and untrained. The handball players participated in a minimum of 8 weekly training sessions lasting be-

tween 90 and 120 minutes, participating in the 2nd handball league of Romania. Each of them was able to train. Stability determination was performed during the competitive season. The untrained girls were healthy students with normal daily activity. The characteristics of both groups are in Table 1.

Table 1. *Anthropometric characteristics of the subjects*

	Trained (n = 19)		**Non-trained (n = 21)**	
	Mean	Std. Deviation	Mean	Std. Deviation
Age (years)	21.67	3.33	21.62	2.42
Height (cm)	171.5	4.82	163.3	5.96
Weight (kg)	57.26	7.33	57.26	7.33
BMI (kg/m2)	23.41	2.57	21.34	2.16

The 2 groups of girls were measured on different days, being informed about the purpose of the measurements, each of them receiving an individual sheet of evaluated the results. In the case of handball players, the data were used to optimize sports training. The untrained girls had the option to understand the stability level of their lower body and receive guidance to improve it. Our study sample consented to the collection and use of results for scientific purposes.

Stability was measured in 2 gyms with similar environmental characteristics. The study subjects were organized in such a way that crowding and long waiting times were avoided.

Stability estimation was performed with the MFT Challenge Disc 2.0 (Bodyteamwork GmbH). The device collects data related to the subject's ability to hold a balance disc horizontally. A sensor is mounted on it that transmits the values in real time via bluetooth to an electronic device running the dedicated software. We used a laptop with a diagonal of 15.6 inches, which we placed at knee level, with the screen facing the subject. Each girl knew during the test what moves she had to make to get the best possible result. This was due to the intuitive interface of the software which presents on the screen 5 concentric circles whose area a disc moves. The equipment allows several ways of use. We chose the measurement mode.

We wanted to analyze the stability through 2 ways of podal support: bilateral and unilateral. In the first case, the subject climbed with both feet on the balance disc, following the instructions of the software. At the end of the measurement, a balance index was calculated whose value was between 1 and 5. Its recommended standard value was between 1.6 and 3.2. The unilateral measurement involved maintaining balance on the disc by stepping alternately with the legs, the duration assigned to each being 20 seconds, with a 15-second break in between. The completion of the test was

marked by the immediate display of the results on the screen, for each part the test index was calculated. At the same time, the percentage difference between the 2 legs is provided, the optimal recommended value being below 10%. Each of the 2 support options on the balance disc was associated with 2 hand work possibilities. The first time the hands were free to make any kind of movement, but not less than 45° to the trunk, to achieve the best possible stability, the next assessment was carried out with the hands on the hips.

The results were processed with GraphPad Prism (v.9.3.0). Using the ROUT method (Q=1%), we eliminated outliers (n = 1). Summary values are represented by mean and standard deviation. To identify the differences between athletes and untrained girls, the unpaired t-test was applied, the significance threshold being set at 0.05. The global observation of the differences between the 2 studied groups involved the One-way Anova test, being processed the results of balance and one-way.

Results

The results of the stability testing of the 2 groups are in Table 2. Each variable has on the right side the results of the t-test showing whether there are differences between female athletes and non-trained girls.

Table 2. *Balance scores in bilateral and laterality situations of practicing and non-practicing women*

	Trained (n = 19)	**Non-trained (n = 21)**	**t test**
MFT_FA_BIL (1-5)	3.32 ± 0.66	2.79 ± 0.84	t=2.189; df=38; p=0.0348
MFT_FA_L (1-5)	3.41 ± 0.67	2.37 ± 0.64	t=4.950; df=37; p<0.0001
MFT_FA_R (1-5)	3.28 ± 0.67	2.31 ± 0.63	t=4.587; df=36; p<0.0001
MFT_FA_LAT (1-5)	14.53 ± 7.68	15.28 ± 12.46	t=0.2254; df=37; p=0.8229
MFT_HOH_BIL (1-5)	2.89 ± 0.66	2.43 ± 0.59	t=2.329; df=38; p=0.0253
MFT_HOH_L (1-5)	3.13 ± 0.68	2.20 ± 0.60	t=4.536; df=37; p<0.0001
MFT_HOH_R (1-5)	3.06 ± 0.70	2.24 ± 0.50	t=4.196; df=36; p=0.0002
MFT_HOH_LAT (1-5)	17.53 ± 11.51	17.53 ± 10.83	t=0.000; df=36; p>0.9999

FA – free arms; BIL – bilateral; L – left; R – right; LAT – laterality; HOH – hands on hips

Non-trained girls had significantly lower scores, compared to handball players, in both measurement modalities: bilaterally and unilaterally. Considering the assessment of stability in the bipedal position with free arms, the group without sports training obtained a score of 2.79 ± 0.84, while the handball players had 3.32 ± 0.66, the value of p reaching 0.03, which implies significant differences. The same tendency was found in

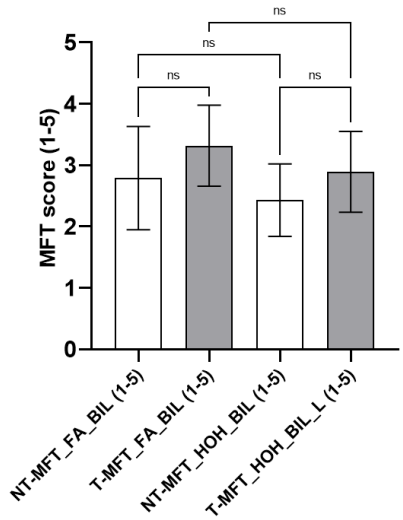
the case of following the same protocol, but with hands on the hips, handball players having 2.89 ± 0.66, and the non-practitioners 2.43 ± 0.59 (p=0.02).

Considering the testing from the unilateral position, the same situation is noted, the values of the group of girls who do not practice any sports discipline are lower than those of the players (free arms - left: 2.37 ± 0.64 vs. 3.41 ± 0.67, right: 2.31 ± 0.63 vs. 3.28 ± 0.001; hands on the hips – 2.20 ± 0.68, with p<0.0001, right: 2.24 ± 0.70, with p=0.0002

In contrast, related to the percentage difference between the 2 scores from unilateral testing both in the position with hands on hips (17.53 ± 10.83% vs. 17.53 ± 11.51%, p >0.99) and with free arms (15.28 ± 12.46% vs. 14.53 ± 7.68%, p=0.82), both groups were at the same level.

The results of the Anova test graphically captured in Figures 1 and 2 indicate differences in balance between female and trained handball players. The score registered by sportswomen in the case of bilateral support on the disc significantly exceeds that of the control group ($F_{(3, 76)} = 5.459$, p =0.0019). Its value is higher for handball players, implicitly the stability being less. Hand position does not seem to influence the test score (Figure 1).

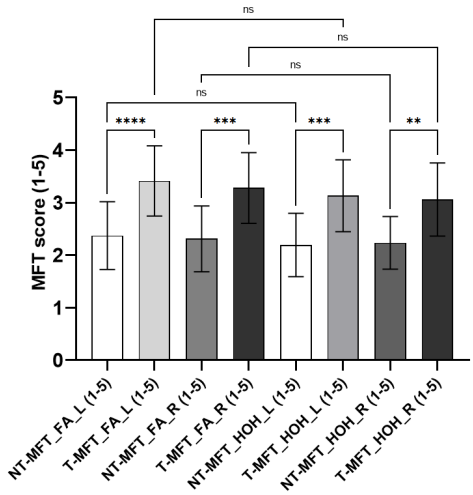
Figure 1. *MFT test score for evaluation with bilateral support*



In the case of testing in a unilateral position, contrary to expectations, the group of handball players had a higher score in the case of both lower limbs and both protocols (hands on hips, free arms), which reflects a precarious level of stability, compared to the group of non-practicing girls ($F_{(7, 146)} = 12.56$; p<0.0001; Figure 2).

Also, the graph demonstrates that the position of the hands does not influence the scores played in this case either. Results recorded at the same assessment position (unilateral) but different protocols (hands on hips, arms free) are similar, with neither providing an advantage in maintaining stability.

Figure 2. *MFT test score for evaluation with unilateral support*



Discussion

Our research aims to highlight the importance of playing a sport for improving balance, as it relates to individual muscular capacity. The results of our study unexpectedly demonstrate the opposite. It seems that the score obtained by sportswomen is higher, which results in a lower stability of the lower limbs.

There is a need to understand this phenomenon and caution in generalizing our results. We state this because there could be influencing factors that have driven these trends in the data. It is possible that the period during which each group was evaluated may have facilitated a better result of the untrained girls. Most of the girls in the 2nd group have practiced sports activities in the past. The difference in demand between the 2 groups may have led to such a result, considering the fact that the handball players were in the competitive period. However, there is a percentage difference between parts in both groups that is higher than that recommended by the manufacturer (below 10%). This could result in a risk of injury through intense physical exertion.

Among men, some researchers have found higher values of the mean center of pressure swing speed and the standard deviation of the velocity in the mediolateral plane

in the trained compared to the untrained ($p<0.05$). In addition to this aspect, they performed stability testing in two situations: eyes closed and eyes open, the first causing significant deviations in maintaining balance (Meshkati, et al., 2010).

Olivier et al. (2019) presented results showing that female performance equestrians had better postural stability with unstable support in the medio-lateral axis compared to the control group (non-executive females).

The influence of sports practice on postural stability has been the subject of several specialists, who made comparisons between amateur and performance practitioners with control groups (non-practitioners). This experimental model has been applied in many sports disciplines such as dance (Stins, et al., 2009), football (Bieć & Kuczyński, 2010; Palmer, et al., 2015), volleyball (Agostini, et al., 2013), rugby (Chow, et al., 2016), kitesurfing (Luz, et al., 2016) or running (Seidel, et al., 2017). In the case of kitesurfing athletes as well as non-practicing athletes, the distance recorded in the medial, posteromedial, posterior and posterolateral directions was similar between the two groups and the assessments of both limbs, while it was also greater than the other directions (anterior, anteromedial, lateral and anterolateral). Also, the athletes obtained better results compared to those in the control group in the medial, posteromedial, posterior and posterolateral directions, both with the right and left leg, and in the lateral direction only with the right leg ($p<0.05$) (Luz, et al., 2016). Given the dance, the practitioners had fewer and smaller swings (smaller swing amplitude and area), resulting in more stable balance compared to the control group (Stins, et al., 2009).

Bieć & Kuczyński (2010) found that soccer players (13 years old) had better stability, especially in the medial-lateral plane. The variability of the center of pressure was significantly higher in the control group than in the soccer ball, both under normal (eyes open, $p<0.05$) and complex conditions (eyes closed, $p<0.0005$). Specialists concluding that players have better postural stability and much less visual dependence than non-athletes. Rugby players were better in balance, with scores 1.06–14.29% lower than the control group. The differences between practitioners and non-practitioners being significantly higher ($p<0.05$) (Chow, et al., 2016).

Athletes had a superior performance when testing static balance compared to non-practitioners (3.26 ± 0.16 points vs. 3.88 ± 0.17 points). The differences between the results were significant, the main effect of group being $F(1,31) = 6.857$, $p=0.014$.

Garza et al. (2024) concluded that there are no significant differences between the group of athletes and the control group, of non-practiced ones, regarding the scores obtained in the Y-balance test (anterior: $p=0.113$, postero-medial: $p=0.567$, postero-lateral: $p=0.542$). Also, athletes had significantly poorer ankle stability than non-athletes.

In the case of gymnastics, some researchers have found differences between gymnasts, practitioners of other sports disciplines and non-practitioners. Following the center of pressure, significant differences were found between the gymnast group and the control group (p=0.049) in terms of mediolateral deviations. Compared to all deviations of the center of pressure, the control group recorded lower scores than female athletes practicing other sports (p=0.005), the same tendency being found for swing speed (p=0.010) (Sloanhoffer, et al., 2018).

Mayer et al. (2022), in their study, aimed to compare the results of unilateral and bilateral testing, performed with the MFT Challenge disc, between male and female handball players, as well as between their age categories. They found higher scores among players, regardless of age, compared to handball players (16-19 years: 4.2 ± 0.3 vs. 3.2 ± 0.4, 20-29 years: 4.3 ± 0.4 vs. 3.4 ± 0.7, over 30 years: 4.3 ± 0.6 vs. 3.6 ± 0.8). They also found that, with increasing age, the scores followed the same trend, indicating a decrease in postural stability assessed in the bipedal position with advancing years. Compared to the unilateral testing, the same tendency is observed, the scores are higher with increasing age, both in the dominant leg (16-19 years: 3.2 ± 5.7, 20-29 years: 3.4 ± 0.7, over 30 years: 3.6 ± 0.8), as well as the non-dominant one (16-19 years: 3.1 ± 0.6, 20-29 years: 3.4 ± 0.6, over 30 years: 3.4 ± 0.6) (Mayer, et al., 2022).

Endurance training has the ability to evoke changes in postural control and improve balance (Marques, et al., 2017). It induces balance improvements in both dynamic and static components.

Conclusion

Measuring and monitoring balance in performance sport can have benefits for maintaining the health of athletes, through specific interventions that could optimize performance levels. On this way, it is possible to intervene on the dosage of the effort that could be adapted to the motor responses within such tests.

Assessing balance in people who have a normal life, without involving special physical performances, could identify deficiencies in posture or muscle tonus that can be addressed through physical exercises.

The difference in balance between athletes and untrained girls exists, in our case being one that disadvantages the first category. Therefore, our hypothesis was disproved. Both groups are at risk of injury and the need for preventive interventions.

We believe that investigations on other samples are necessary, with an in-depth look at the factors that could influence the balance in order to conclude whether our results generalize or present particularities that prevent this.

Author Contributions

Conceptualization, P.F.T. and C.M.A.; **Resources**, P.F.T. and C.M.A.; **Methodology**, P.F.T. and C.M.A.; **Investigation**, P.F.T. and C.M.A.; **Data curation**, P.F.T.; **Formal Analysis**, P.F.T.; **Writing – original draft**, C.M.A.; **Writing – review & editing**, P.F.T.
All authors have read and agreed to the published version of the manuscript.

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