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THE COMPATIBILITY OF MEASURING LEG STABILITY WITH THE Y BALANCE TEST AND *MFT* CHALLENGE DISC IN ADOLESCENTS

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Abstract: *The study proposes the analysis of the compatibility between two methods of assessing leg stability: Y Balance Test (YBT) and the MFT Challenge Disc (MFT). 48 adolescents aged between 15 and 19, from the Moldova region (Romania) were measured. In girls, unilateral indexes correlated positively for both YBT ($r = 0.73$; $p < 0.001$) and MFT ($r = 0.55$; $p = 0.001$). Boys showed a relationship between the Y coefficient of the right leg and the MFT score ($r = 0.51$; $p = 0.03$). Overall, there are correlations between unilateral coefficients within each test, with only YBT having links between the score and the coefficient of the right ($r = -0.33$; $p = 0.02$) and left ($r = 0.57$; $p < 0.001$) leg. No links were found between the results of the two tests measuring leg stability in the respective teenagers.*

Key words: *balance, assessment, posture, youth, motor ability.*

1. Introduction

Adolescence is described as the period of biological, psychological and social transformation that makes the transition from puberty to adulthood. A primary factor influencing stability is the dimensions of the body [9].

Balance is an essential factor in sport and elsewhere. Known as postural control, it can be defined as static and dynamic [19].

Stability and dynamic control of the lower limbs are fundamental aspects of biomechanical functioning and human performance, having a significant impact on the individual's ability to perform efficient movements and prevent injury. In recent decades, research in the field of rehabilitation and sports sciences has paid increasing attention to the development and validation of methods for assessing leg stability that are as effective as possible. One of these assessment tools is the Y Balance Test (YBT). It has become increasingly popular due to its reliability and validity, studies showing that YBT should be used to assess dynamic balance, providing consistent and repeatable results even across different evaluators [1], [11], [15].

YBT is a simplified version of the Star

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Excursion Balance Test (SEBT) to test only the anterior, posteromedial and posterolateral directions [15].

In healthy adolescents, YBT is reproducible for assessing dynamic balance. It has good relative reliability and low measurement standard errors, as well as good absolute reliability. Stabilization of results is observed after the second measurement attempt [7, 10].

Testing using the MFT Challenge Disc Bluetooth 2.0 involves using motion sensors and Bluetooth technology to assess a person's ability to maintain stability and postural control during various activities performed on a balance disk. Although several studies have successfully used Computerized Wobble Board (CWB) based instruments to determine and/or develop stability and to determine lower limb asymmetries, the validity of the specific use of the MFT Challenge Disc has been studied less [3, 4], [18].

The results obtained with the MFT Disc Challenge Bluetooth 2.0 may be influenced by the dominant foot which may perform better due to its higher stability [12].

YBT is a tool used to assess dynamic balance and stability of the lower limbs. The MFT Challenge Disc, on the other hand, is a platform that provides various cognitive and brain function tests using digital technology. To our knowledge, there are no studies investigating our hypothesis that the two testing methods generate results that correlate with each other.

The aim of the study is to analyze the correlation between the results obtained by using two methods of foot stability testing: YBT and MFT. The results of our analysis could be used towards the selection of a suitable method for equilibrium determination.

2. Material and Methods

Our research was designed to verify the correspondence between 2 means of measuring leg stability: the Y balance test and the MFT Challenge Disc. Their application was done once to analyze the results in agreement with our hypothesis. Subjects were 30 girls and 18 boys between the ages of 15 and 19 years old, attending high school in the eastern part of Romania (Moldova). A good proportion of them had exposure to school dropout, thus benefiting from participation in a school recovery project. Their demographic characteristics are presented in Table 1.

Table 1

Demographic characteristics of measured adolescents

	Girls (n = 30)		Boys (n = 18)	
	Mean	SD	Mean	SD
Age (years)	16.67	0.99	16.67	1.04
Height (cm)	163.00	7.08	163.00	7.04
Weight (kg)	57.72	9.49	57.72	7.49
BMI (kg/m2)	21.70	3.09	21.70	2.58

The main selection criteria were the lack of physical difficulties that could have influenced the results.

The measurements were taken in the summer of 2023, in a hall of the Faculty of Physical Education and Sport in Iasi (Romania). The subjects were tested by organizing them in 2 series, so that the allocated space would not be too crowded. First the Y test was conducted, then the MFT.

The Y-test is a solution for identifying differences between the two lower limbs. Before starting to determine the distances the subjects can reach by pushing the moving part of the kit, the required lengths were measured in the calculation formula. Each adolescent was laid on a mattress, and with a metric tape we determined the distance from the anterior superior iliac spine to the medial malleolus. Afterwards, explanations were given regarding the conduct of the test. Within the available space in the room, subjects performed the test 3 to 4 times, or as many times as necessary to pass, before stepping onto the test kit. Upon stepping onto the centre piece of the test kit, the left foot is positioned centrally on it, followed by the right foot pushing the movable piece as far forward as possible. Upon reaching the maximum distance, one returned to the original position without touching the ground with the execution foot. Return was made to the ground behind the central square of the kit, after which the side was switched. In the same order of placing the legs, the execution was continued for the arms on the left and right side respectively. If the ground was touched by the executing leg, the execution was repeated. The moving part of the kit was fitted with a range-finder, which allowed distances to be determined accurately, even down to the millimetres. The y-index of a part (right or left) was calculated according to the formula Y = (A+PM+PL)/(3*L)*100, where: A - anterior distance, PM - postero-medial distance, PL - postero-lateral distance, and L - limb length. The way the index is calculated indicates that its value is directly proportional to performance. The test score (Y%) represented the percentage difference between the 2 indices. The lower its level is the higher the stability.

The MFT test is a solution for measuring lower body stability by analysing the ability to maintain horizontally a balance disc connected via bluetooth to a control device (tablet or laptop). The device we used, the MFT Challenge Disc 2.0 (Bodyteamwork GmbH) was connected to a laptop whose screen was visible to the subject when they stepped on the disc. The “Self check” mode was selected offering 2 measurement options. The first was for both legs and the second for the alternative assessment. We opted for the second option. The software installed on the device gave the necessary indications for conducting the test. Immediately after the selection, the test began by indicating that the subject should step onto the device with the right foot and try it on, which gave each subject the opportunity to get used to the equipment. The task was to maintain a green ball inside a target consisting of 5 concentric circles, the grouping being ascending from the central to the marginal one. The adaptation for the test lasted 15 seconds, after which the measurement began. The measurement lasted 20 seconds, during which time the score varied between one and five. At the end of the test, there was a 15-second pause followed by a restart

with the left foot. The longer the ball was held in circle one, the lower the score, so the result was inversely proportional to performance. The completion of the test was accompanied by the display of the index for the left foot (MFT-L), the index for the right foot (MFT-R), and the test score (MFT%). The latter represents the percentage difference between the first 2, a value below 10% being recommended for a good state of body balance.

The entire testing protocol complied with the Declaration of Helsinki, with each subject having a written agreement for the assessment.

The recorded data entered an analysis process after being electronically centralized. GraphPad Prism software was used. Using the ROUT method (Q = 1%) outliers were searched for and eliminated. No such results were found. The central tendency parameters were then calculated for each data series. These were represented by the mean and standard deviation (SD). Differences between girls' and boys' results were made with the unpaired t-test. The correlations which could validate our hypothesis were assessed by calculating the Pearson r-index and the corresponding significance threshold was set at the 0.05 level. The strength of correlation was assessed according to Zou et al. [20].

3. Results

The results tracked the level of lower limb stability of the measured teenagers by gender and the degree to which there are correlations that could link the two methods we used. The parameters of the two tests were compared between girls and boys (Table 2).

Measurement results by gender Table 1

	Girls (n = 30)	Boys (n = 18)	p
Y-L	88.50 ± 7.16	90.21 ± 8.29	0.453
Y-R	88.73 ± 7.44	89.85 ± 5.07	0.575
Y%	-0.44 ± 6.29	-0.24 ± 8.93	0.930
MFT-L	2.81 ± 0.82	3.10 ± 0.83	0.240
MFT-R	3.04 ± 0.94	3.27 ± 0.70	0.378
MFT%	18.43 ± 14.25	13.17 ± 9.89	0.175

Y-L – YBT index for the left side; Y-R – YBT index for the right side; Y% - YBT score; MFT-L – MFT index for the left side; MFT-R – MFT index for the right side; MFT% - MFT score

Girls' Y-indexes were similar to boys', with no significant differences found for the left side (p = 0.453) or the right side (p = 0.575). The same was found for the Y score (p = 0.930).

In the case of the MTF test, the gender difference is similar to that of the first test. On both the left (2.81 ± 0.82) and right (3.04 ± 0.94) sides, the mean Y coefficient of girls was better than that of boys. At the same time, the difference was found to be insignificant.

The purpose of determining the parameters we analysed is to identify whether there are differences between the 2 sides of the lower body that could endanger bodily integrity. The Y test showed close values in girls (t = 0.2402, df = 29, p = 0.812) and boys (t = 0.1806, df = 17, p = 0.859). Between the right and left

sides of girls (t = 1.544, df = 29, p = 0.133) and boys (t = 1.372, df = 17, p = 0.188), the MFT test followed the same trend as the first test.

There is a difference between the Y score and the MFT score in both girls (t = 6.636, df = 58, p < 0.0001) and boys (t = 4.270, df = 34, p < 0.0001).

Three correlations were identified in the girls' group (Table 3), each of them between parameters of the same method. The lower limb coefficients for the Y-test show a moderate positive correlation (r = 0.73, p < 0.0001). In addition, also in this test there is a weak negative correlation between the right leg coefficient and the test score (r = -0.39, p < 0.05).

In the MFT, only a moderately positive correlation is established for the 2 limbs (r = 0.55, p < 0.01).

Correlations between indices and test scores in girls Table 2

	Y-L_G	Y-R_G	Y_G%	MFT-L_G	MFT-R_G
Y-R_G	0.73****				
Y_G%	0.34	-0.39*			
MFT-L_G	0.09	-0.04	0.19		
MFT-R_G	-0.05	-0.19	0.21	0.55**	
MFT_G%	-0.09	-0.17	0.11	-0.26	0.22

Y-L_G – girls' YBT index for the left side; Y-R_G – girls' YBT index for the right side; Y_G% - girls' YBT score; MFT-L_G – girls' MFT index for the left side; MFT-R_G – girls' MFT index for the right side; MFT_G% - girls' MFT score; * – p < 0.05; ** – p < 0.01; **** – p < 0.0001.

In the Y-test, boys show (Table 4) a strong positive correlation between the Y-index of the left lower limb and the Y-test score (r = 0.82, p < 0.0001). In the MFT, there is a moderately positive correlation between the indices of the 2 sides (r = 0.78, p < 0.01), as well as the index of the left leg with the test score (r = 0.50, p < 0.05). Also in this group, a moderately positive correlation was established between the Y-index of the right leg and the MFT test score (r = 0.51, p < 0.05).

Correlations between indices and test scores in boys Table 3

	Y-L_B	Y-R_B	Y_B (%)	MFT-L_B	MFT-R_B
Y-R_B	0.29				
Y_B %	0.82****	-0.30			
MFT-L_B	-0.24	-0.08	-0.16		
MFT-R_B	-0.04	0.04	-0.06	0.78***	
MFT_B%	0.43	0.51*	0.10	-0.50*	-0.07

Y-L_B – boys' YBT index for the left side; Y-R_B – boys' YBT index for the right side; Y_B% - boys' YBT score; MFT-L_B – boys' MFT index for the left side; MFT-R_B – boys' MFT index for the right side; MFT_B% - boys' MFT score; * – p < 0.05; *** – p < 0.001; **** – p < 0.0001.

We wanted to observe the relationships between the parameters determined in the whole study sample. All correlations identified in the two genders are integrated here. The Y-test index of the left limb shows a moderately positive

correlation with that of the right limb ($r = 0.58$, $p < 0.0001$), as does the y-test score ($r = 0.51$, $p < 0.0001$). A moderately positive correlation ($r = 0.63$, $p < 0.0001$) is identified between the right and left leg on the MFT, and a slightly negative one ($r = -0.35$, $p < 0.05$) between the left and the test score (Table 5).

Correlations between indices and test scores for all subjects Table 4

	Y-L	Y-R	Y (%)	MFT-L	MFT-R
Y-R	0.58****				
Y%	0.57****	-0.33*			
MFT-L	-0.03	-0.04	0.03		
MFT-R	-0.03	-0.13	0.10	0.63****	
MFT%	0.05	-0.04	0.10	-0.35*	0.12

Y-L – YBT index for the left side; Y-R – YBT index for the right side; Y% - YBT score; MFT-L – MFT index for the left side; MFT-R – MFT index for the right side; MFT% - MFT score; * – $p < 0.05$; **** – $p < 0.0001$.

4. Discussions

The aim of our research is to test whether the two methods of testing lower limb stability can complement each other, so that selection within a test battery becomes an easy process.

The only significant correlation through which the 2 methods we used interact was identified in the boys' group, linking the Y coefficient of the right lower limb to the MFT score. Otherwise, the statistically tested links showed interconnections within the YBT and MFT, which gives validity to their application among adolescents.

We found moderately positive links in girls between both legs on both tests. This is no longer true in boys, with only the MFT having a moderate to strong interaction of this type. Interestingly, negative correlations are identified between the right side and the y-test score in girls, and between the left side and the MFT score in boys. This could translate into the fact that if the girls' right side index increases, the y-test score will decrease. In boys, if the left side stability is improved, the MFT score will have the same behaviour. It follows that girls would have a slight deficiency on the right side and boys on the left. This is not supported by the y-test analysis, the result of which indicates insignificant differences between both sides and genders.

The correlation through which the right leg index from the y-test and the MFT score positively influence each other explains that an increase in right side stability would create a greater bilateral imbalance that can be sensed by the MFT test. In this way, we found a link between the 2 tests, but that cannot support their supplementation among adolescents. At the same time, the limitation may be due to the small number of subjects.

Although motor clumsiness in adolescents and increased susceptibility to injury have long been speculated and researched, there is no consensus on how they affect injury risk. Current findings indicate that many aspects of sensorimotor function continue to mature throughout adolescence, with some children experiencing developmental delays in some mechanisms. What is not

clear is how specific sensorimotor mechanisms develop throughout adolescence or how these mechanisms contribute to injury risk in adolescents. Assessments of the methodological quality of the studies identified in the review highlight several important directions for future research: data should be collected in a repeated measures format, designs should allow for analyses of significant gender differences and inter-subject variability, and multiple developmental measures should be used to provide a more robust picture of the evolution of sensorimotor function throughout adolescence. Future studies would also greatly benefit from using measures known to be sensitive and specific enough to capture subtle differences between subjects and analytical tools capable of presenting the temporal order and structure of movement data [13].

The Y-Balance test is one of the few field tests that have demonstrated predictive validity for injury risk in an athletic population. Thus, in sport, the process of postural balance control is essential for individual and collective action. A study of young football players investigated the relationship between YBT scores and stabilometric parameters. It was found to be weakly related in adolescents, examining different types of dynamic balance [16].

The Y-Balance test was used in a study targeting age and gender specific reference values for healthy young people. Evaluated subjects ranged in age from 10 to 17 years old. Differences were made between right and left leg stability and the test score was calculated. Boys aged 16-17 performed better than boys aged 10-14, and girls performed better than boys aged 10-11 compared to 12-13 [14].

Comparison of the YBT with the dynamic balance test showed close results for the 2 stability measurement methods. The latter has a higher accuracy, is performed faster and is much simpler to use [6].

In 79% of athletes analysed by Smith et al, one or more asymmetries in functional reach were found, regardless of gender. Even though girls had better normalised distance, asymmetries were equally prevalent in both gender groups. Asymmetries in the Posterolateral (PL) and Posteromedial (PM) directions were more pronounced than those in the Anterolateral (ANT) direction, suggesting that ANT reaching is not the only direction of concern when interpreting YBT scores. Test reliability was moderate in the PL and PM directions in adolescents, which could be attributed to their visual dependence. However, reliability was good in the ANT direction, comparable to adults. Measurement error was higher in the PM and PL directions, which may affect the clinical interpretation of the results [17].

López-Valenciano et al analyse the influence of different neuromuscular factors on unilateral dynamic balance in football players. In men, hip and ankle flexibility were important factors, while in women, core stability and hip abductor strength were more relevant. However, regression models explained only modest percentages of YBT performance. Similar results to those found in this study for measures of passive hip abduction and ankle dorsiflexion with knee flexion have been reported in previous studies, indicating that individuals with higher scores in such variables performed better in the YBT and therefore demonstrate superior unilateral dynamic balance. These results are in agreement with findings reported by other studies,

although not all, which found that ankle dorsiflexion at the maximum point with the knee flexed accounted for approximately 20% of the variance in the YBT in physically active adults. This finding could support the hypothesis that changes in ankle dorsiflexion with the knee flexed could influence unilateral dynamic balance through mechanical instability (due to ligamentous insufficiency) and/or functional instability (altered neuromuscular control) [8].

The MFT was used among some teenagers in Austria to measure motor activities and physical activity. Performance on weight differences was tracked, thus obese adolescents scored significantly lower than the BMI underweight and normal weight group ($p < 0.01$) [5].

Two methods of Y-Balance testing were compared: the standardized balance kit (Move2perform, Evansville, In) and testing with a manual device. The test was applied in a middle school classroom. Wooden slats and cloth measuring strips were used for the manual test to match the design of the Y-Balance kit, and the same testing procedure was performed. Between the 2 versions of the test the results were remarkably close, the average difference between the techniques being 0.97 to 3.34 cm for each variable tested [2].

5. Conclusions

Lower limb stability of eastern Romanian adolescents indicates a balance between the 2 sides, with insignificant differences in Y and MFT indices.

In the girls and boys studied by us the stability of the lower body is close in value for each method we used.

In the teenage girls there is a correlation between the stability of the 2 lower limbs for the Y and MFT tests. There are no links between the results of the two methods in the girls' group.

In MFT, boys show a correlation between the two legs. The left leg has two opposite correlations with test scores. In YBT the correlation is strongly positive, while in MFT it is moderately negative

The only connection between YBT and MFT is in boys, where the Y coefficient of the left foot correlates moderately positively with the MFT score. We consider this result as coincidental, the hypothesis of our study being largely disproven.

Our analysis suggests that YBT and MFT may not be mutually supportive, and further studies are needed to determine the precise place of each method in measuring balance.

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